MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 66, No. 2
W. B. No. 1231

FEBRUARY 1938

CLOSED APRIL 4, 1938
ISSUED MAY 9, 1938

SPRINGS THAT MYSTERIOUSLY EBB AND FLOW

By W. J. HUMPHREYS

Intermittent springs.—Here and there occurs a spring that flows a while and stops a while, flows a while and stops a while, day in and day out, year in and year out, to the mental confusion of those who not knowing their cause invent explanations of them as fanciful as a medieval gnome or hobgoblin. There are two kinds of these intermittent springs, namely, the cold-water kind which every physicist understands, and the hot-water kind that not even the chemist fully understands in every particular. The flow of the cold intermittent spring is just the emptying of an underground, air connected (essential for rapid outflow), water cavity by a natural syphon tube. Obviously when the reservoir is emptied to the level of the syphon intake the flow ceases—the spring goes dry and stays dry until the reservoir fills again to the level of the highest bend in the tube whereupon the flow and the stop occur again as before, over and over without end.

The hot-water type, confined to volcanic regions, commonly is called a geyser, even when it just mildly overflows. Its intermittent spurts appear to be the repeated blowing out by steam of an underground reservoir that as often fills up again. Where all this water comes from and how it gets into the steam chamber are not known to the complete satisfaction of everyone. It is easy enough to make a laboratory geyser that works perfectly, but that does not prove that Nature made hers on the same plan—she is very resourceful.

Dry weather springs.—Especially in limestone regions, an occasional spring that has become nearly, or even quite, dry starts flowing again or flowing more strongly on the approach of a general rain, hours before a drop of water has fallen within many miles of its place. Sometimes, though relatively rarely, very little rain, or even no rain, falls in the region of the spring for days, or perhaps weeks, after the flow begins; in which case the spring promptly dries up again. Marked fluctuations of this kind are distinctly drought phenomena; they do not occur when rains are frequent enough to maintain a goodly supply of ground-water. Their explanation is simple: The channel to such a spring leads to a cavity which during a prolonged dry spell, when the seepage into it is becoming less and less, gradually empties, slowly filling the while with infiltered air, until the water pressure at the reservoir outlet, below the surface, is no longer sufficient to force an outflow. If, now, the pressure of the open air should be lowered while that of the rather closely entrapped air in the half-emptied underground reservoir is unchanged, water would be forced out from the place of the greater to that of the lesser pressure, that is, from the half-filled cavity to the open spring. Now a marked decrease of atmospheric pressure is just what happens at the approach of a general rain, often beginning hours ahead of the precipitation; and, as early, causing certain springs to run again in the midst of a drought, or to run more freely if not yet dry—a mysterious flow, prophetic of rain.

Night springs.—Often in the summer time, and especially in dry weather, a weak spring in a deciduous forest runs well at night but feebly, or even not at all, between nine o'clock in the morning and sundown. This is because the ground-water at such localities, as indeed in practically all localities, has two outlets, or two ways of escape, one by seepage and vein-like drainage to springs; the other through evaporation from the myriads of leaves overhead. When evaporation is least, as it is at night, loss by seepage is at its maximum and the spring-flow greatest. When, on the other hand, evaporation is most active, that is, during the warmer daylight hours, tree leakage is largest and spring-flow least, even to complete cessation by mid-afternoon, or earlier. Such is the course and the explanation of the well known, but to few familiar, night spring. In the course of a severe drought such a spring first becomes feeble by day, then flows only at night, and finally neither by day nor at night.

First-frost springs.—From the explanation above of "night springs" it is clear that anything that suddenly would shut off tree evaporation would, during a period of dry weather, as promptly strengthen, or even start afresh, many a small forest spring. Clearly, too, the thing that does just that is the first killing frost of autumn. That is why at times and places springs start up anew, and branches flow again, or stronger at least, immediately after the first heavy frost in the fall of the year, and that too without any precipitation to supply the goodly quantity of water where but a day before there had been little or none.

Such (all the above) are at least some of our mysterious springs—mysterious when we do not understand why they behave so differently from most springs, but all the more interesting when we do.

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GEOGRAPHY AND RAINFALL OF THE NEBRASKA SANDHILLS

By BERTRAM E. HALL [1]

[Weather Bureau office, Valentine, Nebr., November 1937]

North of the Platte River in Nebraska, lies an area of approximately 20,000 square miles within which dune topography prevails; this is the sandhill region, extending from the ninety-ninth meridian on the east to the one-hundred and third meridian on the west. In the north the boundary of the area is marked roughly by the Niobrara River, from which the dunes extend southward, almost without a break, to the valley of the Platte. Some of the sandhills are no more than 25 feet high; others rise 100 feet, or even several hundred feet, above the intervening valleys. In general the hills form lines, cut by numerous basins and depressions, and run in a southeasterly direction; but in the south portion of Cherry County, near the head waters of the Loup River, there are low ranges of hills with a west to east trend. The elevation of the area above sea level varies from about 2,500 feet in the east to approximately 4,000 feet in the west.

The topography of the region is one of alternate hills and valleys dotted with marshes, lakes, lush meadows, and dry basins, many of the small depressions being filled with water. There are about 2,000 lakes, most of them very small, and none very large. The largest is "Dad's Lake," south of Valentine, approximately 5 miles in length and less than a mile wide.

The hills are of local origin. The wind was a prominent factor in the formation of the Nebraska sandhills, for the hills are the direct result of wind action upon soft, sandy bedrock and mantlerock. The numerous lakes are merely depressions scooped out by the wind and filled with water. Such shallow lakes fluctuate widely in size, and in the drier seasons many of them disappear entirely. Some, particularly in the west portion of the area, are highly alkaline, and during the World War, the recovery of potash from the lakes of the Nebraska sandhills gave rise to an active industry.

The soil is loose and sandy, and easily moved by the wind. Most of the region is more or less permanently fixed, but here and there are "blowouts" where the wind has torn away the protecting grass roots and exposed the naked sand to the elements. Such blowouts sometimes produce moving dunes, and are more numerous and of larger size in dry years than in wet years.

In spite of blowouts and small areas of drifting dunes, the sandhill region is essentially a grass region. Between the hills are moist meadow lands where grass grows luxuriantly, and on the uplands are many kinds of grasses and a variety of other plants. It is the grass that furnishes feed for literally hundreds of thousands of cattle, heals the open wounds of festering blowouts, and stops the advance of moving dunes. Numerous flowers bloom from early spring to early fall. The crocus, phlox, wild onion, pentstemons (beard-tongues) and numerous other flowers bloom in the spring and early summer. Later the manroot, a variety of morning glory, is in bloom; and in late summer the sunflower, goldenrod, asters, and blazing star brighten the landscape. The cacti are numerous, and represented by several varieties, but chiefly by the Opuntia (prickly pears) and the pin cushion cactus. Wild roses, wild plums, wild grapes, and wild cherries grow along the banks of the streams, and the yucca covers many a hillside.

In the valley of the Niobrara the Ponderosa pine covers the canyon slopes; and cottonwood, hackberry, willows, and other trees grow along the streams. Small amounts of oak and birch are found in the valley of the Niobrara, particularly east of Valentine. Farther west, in the heart of the sandhills, are two national forests, the Niobrara and the Halsey. The latter has been planted by man, and these plantings, covering about 20,000 acres, have proved that trees will grow in the sandhills if the proper varieties are planted.

The most surprising natural resource of the sandhills is the water supply: The entire region is one of light or moderate precipitation. The soil is sandy and rainfall disappears readily into it, with little surface run-off. A sandy soil heats rapidly, and summer days are often hot. Wind movement is brisk and evaporation high. Yet, in spite of these numerous adverse factors, the springs and streams of the sandhills continue to flow. Surface lakes may disappear, but the underground water supply is sufficient to maintain the sandhill rivers almost undiminished.

The sandhills have been called "the greatest reservoir of underground water in the world." Certain it is that vast quantities of water are stored underground in the Nebraska sandhills. The sand acts as an enormous sponge and drinks up rain as fast as it falls. In places the sand is 300 feet deep, and water-filled all the way down. The statement has been made by Dr. Condra of the University of Nebraska that the sandhills have absorbed one-third of their volume in water. This would mean that in an area where the sand is 300 feet deep there would be about 100 feet of water. This is equivalent to 65 years of annual rainfall at Valentine, located on the northern edge of the sandhills.

The Niobrara River rises in Wyoming and flows eastward, skirting the northern edge of the sandhills. The upper portion of its valley is shallow, but farther east in Cherry County the valley assumes canyon proportions. In Western Nebraska, as in other semiarid regions, streams are intermittent; that is, they disappear during the dry season. The upper Niobrara is no exception, but farther downstream in the deeper portions of its canyon the river has cut down below the level of springs, and become a permanent stream. From Valentine eastward, numerous springs flow into the river and its tributaries are likewise spring-fed. The significant fact is not that the river is springfed, but that the springs have continued to flow during the severe drought years. Many of these springs come from such great depths that they do not freeze even though the air temperature is 20° below zero. In 1934, 1936, and again in 1937 the top soil became so dry that it seemed as if no water could possibly be left anywhere in the soil, but the sandhill rivers continued to flow. In brief, these rivers are made possible by the unsurpassed capacity of the sandhills to store water.

Another such river is the Loup, a typical river of the sandhills. It is actually a system of rivers including the North, Middle and South Loup Rivers, the Cedar River, and Beaver Creek. These five streams all rise in the sandhills, flow southeastward and finally unite as one river which eventually flows into the Platte. The Loup rivers are fed by hundreds of springs in the sandhills; and no matter whether the season is winter or summer, or whether rain falls or not, the volume of water in the Loup changes but little. The visitor who is accustomed

[1] Deceased December 31, 1937.

to seeing rivers dry up during periods of rainless weather cannot but marvel that the sandhills can send forth so much water during periods in which they receive almost none. The secret lies in the ability of the sandhills to absorb and hold water for perhaps several hundred years.

In spite of the vast underground water supply, the surface-water level can and does decline greatly during periods of prolonged drought. The Experimental Farm maintained by the University of Nebraska at Valentine has taken water level readings in seven sandhills meadows several times a year, more or less regularly since 1922. In general, the period from March to June is the period of highest water level, and October is usually the lowest.

In 1934 there was an alarming drop in the water level for all seasons. There were those who said that it would take years for the grass to come back; but the spring of 1935 was wet, the water level climbed upward, and ranchers harvested one of the largest hay crops in the history of white settlement in the sandhills. Again in 1936 and 1937 the level of the surface water dropped discouragingly low. By September 1937 it was the lowest since records had been kept, and many of the smaller surface lakes had disappeared; but the springs and rivers continued to flow, and those who know the sandhills know that even a brief period of above normal precipitation can quickly restore the fallen water level.

Two other rivers should also be mentioned. One is the Snake, a tributary of the Niobrara and resembling the latter in many ways. About 25 miles southwest of Valentine the river has cut deep into the mantlerock and formed the beautiful Snake River Falls. Farther east is the Elkhorn, rising on the eastern edge of the sandhills; it resembles the Loup, but for much of its length it is without the sandhills and is much more likely to rise and fall than the typical sandhill rivers.

The western edge of the sandhill area, where the sandhills come in contact with the "hard lands," may receive some underground water from the Rocky Mountains; but the total amount of such water must be comparatively small.

Precipitation in the sandhills area is typical of the Plains region as a whole. Fall and winter are dry, followed by a precipitation maximum in spring and early summer. Records at Valentine indicate that 60 percent of the annual precipitation falls between April 15 and August 15. Seasonal percentages at Valentine may be considered as typical of the entire area, and are as follows:

Winter (December, January, and February)	1.64 inches or 9 percent.
Spring (March, April, and May)	5.69 inches or 31 percent.
Summer (June, July, and August)	8.05 inches or 44 percent.
Fall (September, October, and November)	2.96 inches or 16 percent.
Year (normal)	18.34 inches or 100 percent.

The following records were compiled from the climatological data of the United States Weather Bureau. The actual average of precipitation is given from the time of the beginning of the record at each specific station to the end of the year 1930, except as otherwise noted.

The average annual precipitation at Valentine for the period ending with the year 1930 was 19.55 inches. This is nearly 7 percent greater than the estimated normal of 18.34 inches stated in a preceding paragraph, but if the Valentine record is continued through the year 1936 it will be found that the average annual precipitation has fallen to 18.98 inches.

Precipitation data for the years 1931 to 1936 inclusive have been compiled separately. These years may be described as the "drought years"; while they include brief periods of above normal precipitation, such periods were of insufficient length to bring the annual totals to normal except in isolated areas.

TABLE 1.—*Precipitation, inches and hundredths, for period ending with year 1930*

	Length of record in years	January	February	March	April	May	June	July	August	September	October	November	December	Year
Ainsworth	31	0.59	0.81	1.36	2.29	3.85	3.69	3.17	3.12	1.99	1.50	0.68	0.93	23.98
Alliance	41	.51	.49	.84	2.04	2.80	2.74	2.72	1.78	1.16	1.13	.46	.49	17.16
Gordon	33	.57	.47	.91	2.02	2.87	2.97	2.61	1.75	1.21	1.21	.62	.67	17.68
Halsey	28	.42	.53	.98	2.45	3.46	3.15	3.25	2.99	1.61	1.49	.59	.73	21.65
Kennedy	42	.43	.64	1.00	2.06	2.61	2.37	2.34	1.74	1.12	.95	.47	.58	16.31
Mary	20	.48	.74	1.18	2.50	3.15	3.04	2.89	3.16	1.60	1.74	.63	.74	21.85
Merriman [1]	17	.48	.39	.76	2.36	3.22	3.38	3.48	1.86	1.40	1.38	.78	.46	19.95
Mullen [1]	17	.36	.45	.80	2.37	2.59	2.59	2.61	1.50	1.03	1.09	.21	.35	15.95
Nenzel	15	.57	.43	1.16	2.12	3.12	3.84	3.12	1.91	1.24	1.35	.84	.64	20.34
North Platte	57	.40	.50	.82	2.10	2.84	3.15	2.68	2.42	1.42	1.16	.50	.55	18.54
Purdum	5	.55	.77	1.17	2.46	3.00	3.35	3.18	2.95	1.53	1.44	.72	.82	21.89
Valentine	42	.57	.55	1.22	2.21	2.75	3.06	2.94	2.44	1.34	1.21	.66	.60	19.55
Whitman	22	.33	.43	1.04	1.84	2.71	2.76	2.79	1.80	.91	.82	.43	.48	16.34

[1] Number of years record as indicated but years not consecutive.

Although each of the six years designated as "drought years" was dry, the most devastating droughts occurred in 1934 and 1936. The year 1930 was severely dry in much of the Middle West, but had above normal precipitation in the sandhills and is not included with the "drought years" in this discussion. The year 1937 is likewise a drought year but cannot be included, as its data have not yet been compiled.

TABLE 2.—*Precipitation: the drought years, 1931–36 inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Ainsworth	0.44	0.78	1.24	2.00	2.98	2.51	1.42	2.28	1.65	0.57	0.39	0.50	16.86
Alliance	.18	.52	.82	2.66	2.10	1.82	1.12	2.04	.69	.38	.35	.40	13.18
Gordon	.38	.43	1.34	2.01	1.92	2.24	1.85	2.15	.69	.52	.44	.53	14.51
Halsey	.23	.48	.89	2.08	3.03	2.50	2.06	3.00	1.88	.43	.29	.83	17.29
Mary	.32	.76	1.13	2.06	4.56	3.17	2.07	1.98	1.37	.60	.43	.53	18.98
Merriman	.42	.52	1.40	2.03	2.60	2.22	1.84	1.79	.75	.72	.55	.50	15.34
Nenzel	.48	.67	1.52	2.05	2.40	2.50	1.90	2.46	.82	.64	.56	.58	16.93
North Platte	.22	.42	.74	2.35	2.38	2.41	1.92	2.06	1.22	.38	.29	.43	14.82
Purdum	.45	.98	2.04	2.36	3.48	2.25	1.79	2.56	1.67	.47	.43	.81	19.06
Valentine	.34	.49	1.57	1.95	2.61	2.31	1.71	1.34	.73	.64	.29	.36	14.87

Table 3 is a composite of tables 1 and 2. Only 10 stations are used: Ainsworth, Alliance, Gordon, Halsey, Mary, Merriman, Nenzel, North Platte, Purdum, and Valentine, in order that the data might be comparable. The table shows the mean precipitation for these stations for (1) the years ending with 1930, (2) the "drought years," 1931 to 1936 inclusive, and (3) the percent of change during the "drought years" as compared with the preceding period.

TABLE 3

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Years ending with 1930	0.51	0.57	1.04	2.26	3.11	3.24	3.00	2.44	1.45	1.36	0.65	0.66	20.28
Drought years 1931–36 inclusive	.35	.60	1.27	2.16	2.18	2.40	1.77	2.17	1.15	.54	.40	.55	16.18
Percent of change	−31	+5	+22	−4	−10	−26	−44	−11	−20	−60	−40	−17	−20

A study of table 3 shows that during the "drought years" there has been a sharp drop in the midsummer and fall precipitation. The average for June 1931–36 inclusive, dropped 26 percent below the average for June for

the years ending with 1930. There was a similar drop of 44 percent in July. Inasmuch as June and July are critical months for corn, there has been no corn crop worthy of the name during the drought years. Yet there have been good hay crops at least 3 years out of the 6, as early spring rains have given the grass a good start before the excessively hot dry weather began. The spring of 1935 was wet, and there was a bountiful hay crop. Good rains likewise fell early in 1933 and 1932, and there were good hay crops during these years, but little corn. The years 1934 and 1936 were extremely dry from early spring to late fall.

Table 3 also reveals a sharp drop in the fall precipitation: a decrease of 20 percent in September, 60 percent in October, and 40 percent in November. Dry weather in the fall has favored duststorms and destroyed winter wheat.

Rainfall is the most variable of meteorological elements; table 4 shows the extremes of record at Valentine for the years 1889 to 1936 inclusive. These data are based on the calendar year. The driest 12 months of record began with September 1933 and ended with August 1934. During this period only 8.78 inches fell.

TABLE 4

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Wettest	1.61	1.55	2.87	7.03	8.18	8.18	7.97	5.02	4.06	4.81	2.74	1.56	28.91
Driest	.04	.04	.16	.12	.17	.32	.04	.33	.08	.00	.01	.03	10.14

A discussion of precipitation in the sandhills area would not be complete without mention of blizzards, thunderstorms, and hail.

The blizzard does not occur as frequently as the public assumes. One of the worst storms of record in the sandhills area was in March 1913; no trains came into Valentine for 5 days. Old timers still talk about the frightful blizzard of 1888. However, such visitations of subzero cold, high wind and heavy snow are fortunately rare. The heaviest snows are most likely to occur in November, March, or even April. On the average, March is the month of heaviest snowfall in central and eastern portions of the sandhills; but farther west, where the altitude is higher and spring more retarded, April is often the month of heaviest snow. The average annual snowfall in the sandhills ranges from approximately 30 to 50 inches, the smaller amounts falling in southern portions along the Platte River.

During the warmer months thunderstorms are frequent. Many small showers, local in character and the result of local conditions, fall in the sandhills. The heavy deluges that sometimes occur are connected with the advance of a cold front and widespread thunderstorms. At Valentine the total number of days with 1.00 inch or more of precipitation for the years 1889 to 1936, inclusive, is as follows: January, 0; February, 0; March, 4; April, 15; May, 22; June, 25; July, 35; August, 21; September, 8; October, 11; November, 2; and December, 0. The greatest precipitation ever recorded in 5 minutes by tipping bucket is 0.80 inch; in 10 minutes, 1.41 inches; in 15 minutes, 1.72 inches; in 30 minutes, 2.51 inches; in 1 hour, 3.02 inches; in 24 hours, 4.21 inches.

Except when snow falls, or during heavy rains of early spring, precipitation of 1 inch or more usually occurs in connection with thunderstorms. Heavy hail falls occasionally, sometimes even mowing the grass, but hail damage in the sandhills is not as great as in more densely populated and agricultural regions.

Evaporation is high in the sandhills area. Hot summer days, brisk wind movement, and low humidity are highly effective for rapid evaporation of moisture, wherever found. No evaporation (data) actually in the sandhills are available, but a record at North Platte has been used in the the compilation of table 5. The data in this table are for the period beginning with the spring of 1927 and continued through the season of 1936, and include, (1) the average monthly evaporation for the period ending with

TABLE 5.—*Evaporation in inches and thousandths*

	April	May	June	July	August	September
1927–30, inclusive	5.509	6.211	5.943	8.909	7.878	6.949
1931–36, inclusive	5.464	6.707	8.411	10.714	8.393	6.431
Percentage of change	−1	+8	+42	+20	+7	−7

the year 1930 (the April average is for 1928, 1929, and 1930 only); (2) the average monthly precipitation for the "drought years," 1931 to 1936, inclusive; (3) the percent of change in the rate of evaporation during the "drought years" as compared with the rate during the preceding period.

The years 1927 and 1928 were slightly above normal in precipitation at North Platte; 1929–30, considerably above normal; 1931–34, below normal; 1935 again slightly above, and 1936 decidedly below normal. The data show that in dry years, when there is less water to evaporate, the potential evaporation is much higher.

The sandhills area is outside the eastern zone of heavy precipitation. "Dry storms," that is, low-pressure areas without any precipitation, often cross the sandhills. When a LOW comes from the northwest it may be followed by cold, or by a duststorm, or both, but it seldom brings precipitation to the sandhills area. When precipitation does fall during the passing of such a LOW, it is usually light. Heavy precipitation in the sandhills almost always comes from a Colorado LOW, or one located somewhat to the east of Colorado. In other words, a LOW coming from the southwest, or south-southwest, brings the heaviest precipitation to the Nebraska sandhills.

During the past few years southwestern LOWS have been fewer than usual, and their occurrence did not always bring precipitation. However, there is no scientific reason for believing that the "drought years" constitute a permanent change in climate. Doubtless the future will again bring more rain to the sandhills, and their recuperative power is amazing.

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THE NORMAL TEMPERATURE DISTRIBUTION OF THE SURFACE WATER OF THE WESTERN NORTH ATLANTIC OCEAN

By GILES SLOCUM

[Weather Bureau, Washington, D. C., February 1938]

During 1937 the Marine Division of the United States Weather Bureau prepared, for the use of the Weather Bureau forecasters at Washington, and as an aid in air-mass analysis, a set of 12 monthly charts of normal water-surface temperature for an extensive region east of the North American continent, including, the Gulf of Mexico, the western half of the Caribbean Sea, and a limited portion of the western North Atlantic Ocean. The boundaries of this region are shown on chart 1.

Since that time, several requests have been received for copies of these charts. In order that such requests may be conveniently filled, and to make the charts available to the public and to such of the Weather Bureau field stations as may find them of value, these charts are now being published.

The data from which the charts have been compiled are water-surface temperatures measured by observers aboard ships cooperating with the Marine Division in the gathering of marine meteorological data. Some of these ships have sent in observations to the Weather Bureau over periods of many years. For instance, the Marine Division records show that the American S. S. *Tivives* has regularly sent in observations since 1919, and at the present writing has completed nearly 19 years of continuous cooperation. The *Tivives* has the longest continuous record under a single name which could be ascertained from an examination of the Marine Division's list of ships at present furnishing observations. There are many other ships with long records, including many ships which formerly furnished observations but which by now have been lost at sea, taken out of service, or for other reasons have ceased sending in observations.

There have been difficulties, largely mechanical, which have made it impracticable to assemble all available records into one summary of normal conditions, hence the period used in the compilation of the present charts includes only the 20 years, 1912 to 1931.

Each day the ship's observer takes one or more observations of a number of weather elements during the time that the ship is under way. The water-surface temperatures are recorded as a part of this routine observation, and those used in the present compilations were taken by either of two methods, namely the "bucket" method, or the "intake" method. The data gathered by ships using these two modes of observation, have been here assumed to be homogeneous and have been combined into one mass of data.

The greater number of the observations, about three-fourths, were made by the bucket method, and the other quarter of the observations by the intake method. The bucket observations are made by drawing up a sample of the surface water from the sea to the deck of the ship in a canvas or metal bucket, and immersing a thermometer, designed for this specific purpose, into the surface water sample. The observer is instructed to stir the thermometer in the water sample until the mercury column comes to a stationary height. The correct temperature of the water sample may then be read from the thermometer. In the intake method of observation, the water temperature is read from a permanently installed thermometer whose bulb is immersed in the condenser intake, where the water flows past the bulb of the thermometer as it enters the ship.

The bucket and intake observations are usually taken at Greenwich mean noon, but a number of ships also record either one additional observation at Greenwich mean midnight, or, three additional observations at 6 p. m., midnight and 6 a. m., Greenwich time. A few observations are made at local noon and at other miscellaneous hours. Except where otherwise noted, all references made in this paper to water-temperature observations are to Greenwich mean noon surface-temperature data.

There are uncertainties and inaccuracies involved in bucket and intake temperatures as observed on commercial ships, and the results obtainable are not suitable for precision studies of oceanographic problems. For such purposes, there are other and more accurate methods, such as the usually satisfactory thermograph sheet record, or the meticulously precise observations made with minutely calibrated instruments by trained scientific workers aboard well-equipped floating oceanographic laboratories. These two classes of precise measurements of surface water temperature are represented by fairly voluminous, but yet comparatively few available, data, gathered along only a few routes. This is a disadvantage when the data are to be used for meteorological and climatological purposes, where wide distribution and abundance of data are more important than extreme accuracy, however valuable such accuracy would be. The bucket and intake observations provide the only material available that fulfill the conditions of wide distribution and abundance.

The total number of observations of these two kinds in existence for all of the oceans is enormous, running well into eight figures, and is hundreds of times as great as the number of available precision measurements of surface-water temperature. The Weather Bureau has approximately 4,000,000 bucket and intake observations. This number has been so great that, until recently, it has been impossible to utilize any large fraction of the collection because of lack of facilities to treat such great numbers of observations. In 1934, however, the Civil Works Administration compiled data from more than 2,000,000 marine meteorological observations. The data were, in this compilation, transferred to Hollerith 45-column punch cards, and tabulated by Hollerith sorting and summarizing machines. Later, the Works Progress Administration undertook further summarizations of marine data on a more extensive scale. These summarizations are being deposited in the Marine Division. The compilations used in the present set of charts were made from the Civil Works Administration data, and it is hoped that normals for other regions may be computed from the Works Progress Administration compilations.

Other meteorological services have prepared similar charts in the past, which covered, in some cases, all or part of the region here treated. The British Meteorological Office has published [1] normal temperatures for 2° squares in chart form for the North Atlantic Ocean, the South Atlantic Ocean, the Indian Ocean, and the Mediterranean Sea. In the British charts, the normals for each square are entered to whole degrees, Fahrenheit, on maps of the oceans covered. The Netherlands Meteorological Institute using the same area unit, has charted

[1] Cf. Marine Observer, Vols., III, IV, V, and VII; Nos 25 to 60, and 73 to 84, inclusive.

the normals to tenths of a degree on the Centigrade scale, for the Atlantic Ocean [2] east of the 80th meridian, from 50° N. to 50° S., and for the Indian Ocean.[3] They have published 1° square normals [4] for the waters off the east coast of Asia from the Equator to 42° N., as far east as 145° east longitude, using the same temperature scale. Five-degree square normals [5] for the North Pacific Ocean and 1° square normals for selected areas along the east coast of Asia, are published in tables by the Japanese Government, using Fahrenheit entries.

Each of these compilations by foreign meteorological offices is based upon great numbers of observations. For instance, the British and the Dutch data were based on more than a million, which number at first thought, might seem adequate for the purpose of computing good normals for the entire ocean surface of the world. When however, a million or two of observations are considered as distributed over two or three oceans, over 12 different months, and over thousands of unit areas in each ocean, the average number of observations per unit area per month is not large. Furthermore, the observations are not distributed with any approach to uniformity. Instead, they are strongly concentrated in the areas traversed by the major ship routes, which are few in number. These routes of most frequent travel are somewhat different for different countries, since each government's data are most concentrated about the routes taken by vessels carrying the main imports and exports of the country. The result is that many portions of the earth's ocean surface are well represented by available observational material, but vast areas in out-of-the-way waters are utterly without representation.

To produce fully adequate normal temperature values for ocean-surface water requires a density of data such as is available from the more frequently-traveled ship routes. This ideal density cannot be obtained for any extensive portion of the globe, but for this one region, the data now made available approach closer to adequacy, quantitatively speaking, than in any previous compilation. This region is, in addition, that of most interest to the weather forecasters for the Eastern States, and therefore, a region for which a closer approach to adequate data is needed.

Although this is the region for which observations available to the United States Weather Bureau are most numerous per unit area, the distribution is very diverse even here, and varies, as shown on chart 1, from one observation per 1-degree square in the entire 20-year period, 1912 to 1931, to an average of about one a day per 1° square, a ratio of about 7,000 to 1. The squares with small circles on chart 1 are those within the region being considered where observations are least plentiful, but where even then, in the majority of 1° square thus designated, they are of about the average density found on the most adequately represented 10 percent of the earth's ocean surface. In these squares on chart 1, there are one, two, or occasionally five or six observations per 1° square for some one or more of the months of the year during the 20 years of record, but no observations whatever in the entire 20 years for some other month or months of the 12 in the year. While no reliable normal temperature can actually be computed for such areas, such data as are available are of some assistance in determining what temperatures are possible in these areas, and we may assume in the majority of cases that area units close to large masses of land have water-surface temperatures somewhere between those of the adjacent waters and those of the nearby harbor waters or of the littoral air temperatures. This does not constitute a really satisfactory approximation, but it is not an entirely worthless estimate, since, luckily, the areas within the limits shown on chart 1 which are so inadequately represented by observational data are small in size, embracing at most only a few 1° by 1° unit areas.

The squares with one diagonal on chart 1 are those for which some data are available for each month of the year for every 1° square. It is to be understood, however, that this is *not* the same as one or more observations for each of the *240* months in the 20 years, but only one or more for each of the *12* months of the year.

The upper limit in the number of observations in these squares is an average of 30 observations for each of the 12 months, or an average of 1½ observations a month during the 20 years. While the quantity of data assembled for these squares is still not sufficient to allow of making dependable normal temperature values for each 1° square, the support of data in the surrounding squares makes estimation of the approximate position of the isotherms possible.

The squares with two diagonals, more than half of the region included in the compilation, are those where 1° square normals are based on 31 or more observations, but on less than 190.[6] This is a more adequate number of observations for determinations of normal temperature, and averages computed from this many observations are probably almost as near to the true normal temperature as the use of a period of only 20 years can produce. This is because 20 years is so short a period to use in computing a normal surface-water temperature, that the variations in actual temperature about the normal for particular months and the semisecular trends in water-surface temperatures, limit the accuracy of the normals computed from the 20-year averages, however, accurately those 20-year averages be known.

The squares with black circles in addition to two diagonals are those where 191 or more observations are available for each monthly normal. With so plentiful a density of data as in these areas, it is possible, by combining several of the 1° squares into one group, to compile temperature history tabulations of small areas so as to make detailed studies of local condition .

In general, in spite of the great inequalities in the numbers of observations per unit area, there is a fair number of observations available for each of the majority of squares, and even where the density is inadequate, there are more data included in the present 1° square normals than have hitherto been used in computing the normals for areas four times as large, namely those compiled on the 2° square basis by other meteorological services. The Marine Division observations are so distributed that some of the spots which have been blanks, or have been represented by very scattered and scanty data on previous chartings, are, in the present set of charts, represented by considerable data. This is especially true for the portion of the Caribbean Sea included in this study. Previous compilations have been based upon records largely gath-

[2] Cf. Koninklijk Nederlandsch Meteorologisch Instituut, No. 110; Oceanographische en Meteorologishce Waarnemingen in den Atlantischen Oceaan. 4 vols.

[3] Ibid; Oceanographische en Meteorologische Waarnemingen in den Indischen Oceaan. 4 vols.

[4] Ibid; No. 115; Oceanographische en Meteorologische Waarnemingen in de Chineesche Zeeen en in het Westelijk Deel van den Noord Stillen Oceaan. 2 vols.

[5] The Mean Atmospheric Pressure, Cloudiness, Air Temperature, and Sea-surface Temperature of the North Pacific Ocean and the Neighboring Seas (English translation of title) Text in Japanese and English. Latest edition includes period from 1911 to 1935, inclusive.

[6] This arbitrary upper limit was chosen because when the density of observations per 1° square was originally charted, the results were tabulated to the nearest integral number of observations per 1° square per individual month. In particular, 31 to 190 observations for a normal temperature compilation value are the same as 2 to 9 observations on the average per individual month.

Chart 1. Density of Observations in Water Area for Which U. S. Weather Bureau Data are Used (Plotted by Giles Sloan)

Chart 1. Density of Observations in Water Area for Which U. S. Weather Bureau Data are Used

(Plotted by Giles Slocum)

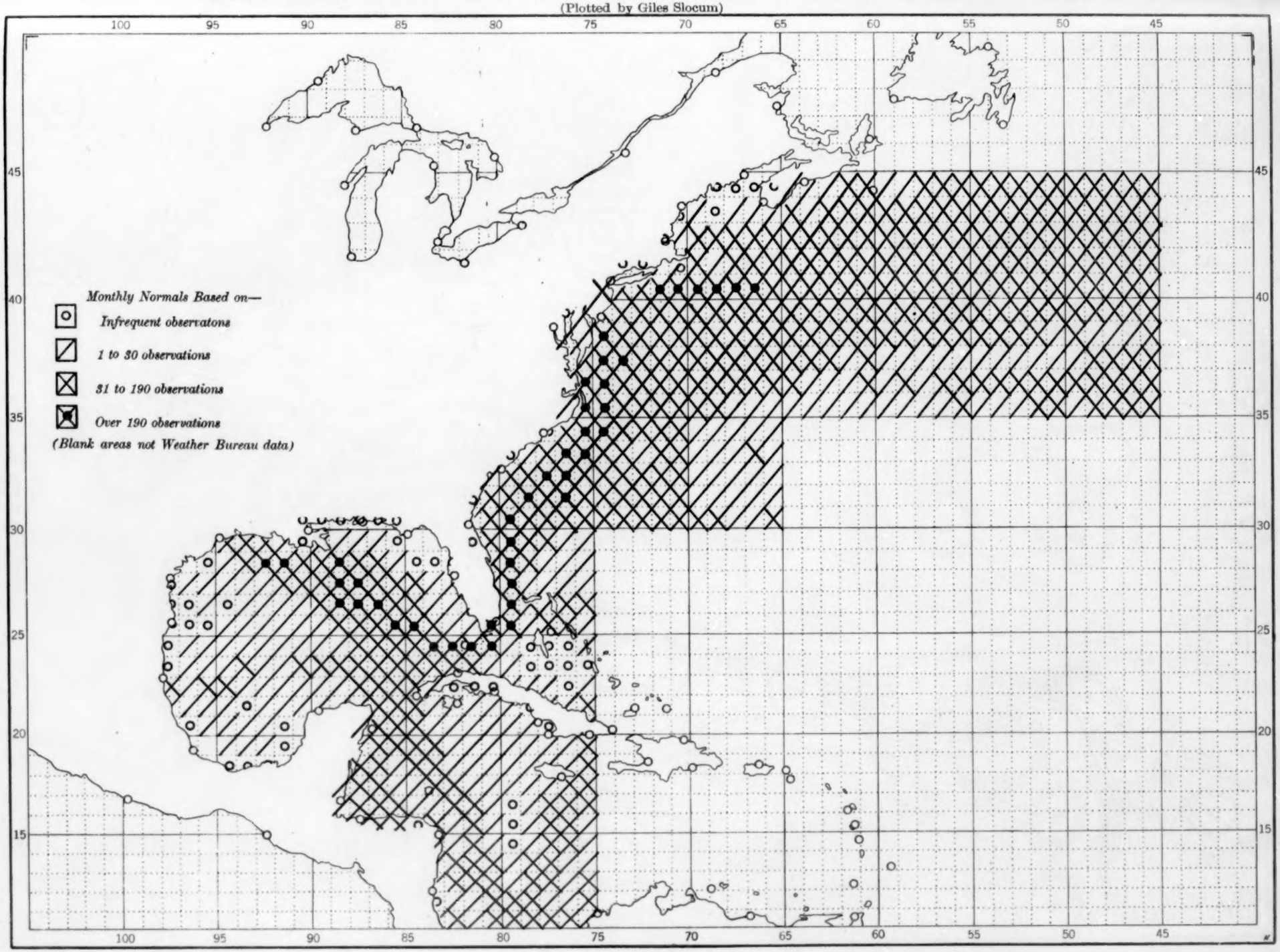


Chart 2. Average Sea-Surface Temperature (°F.) for January 1912-1931

(Plotted by Giles Slocum)

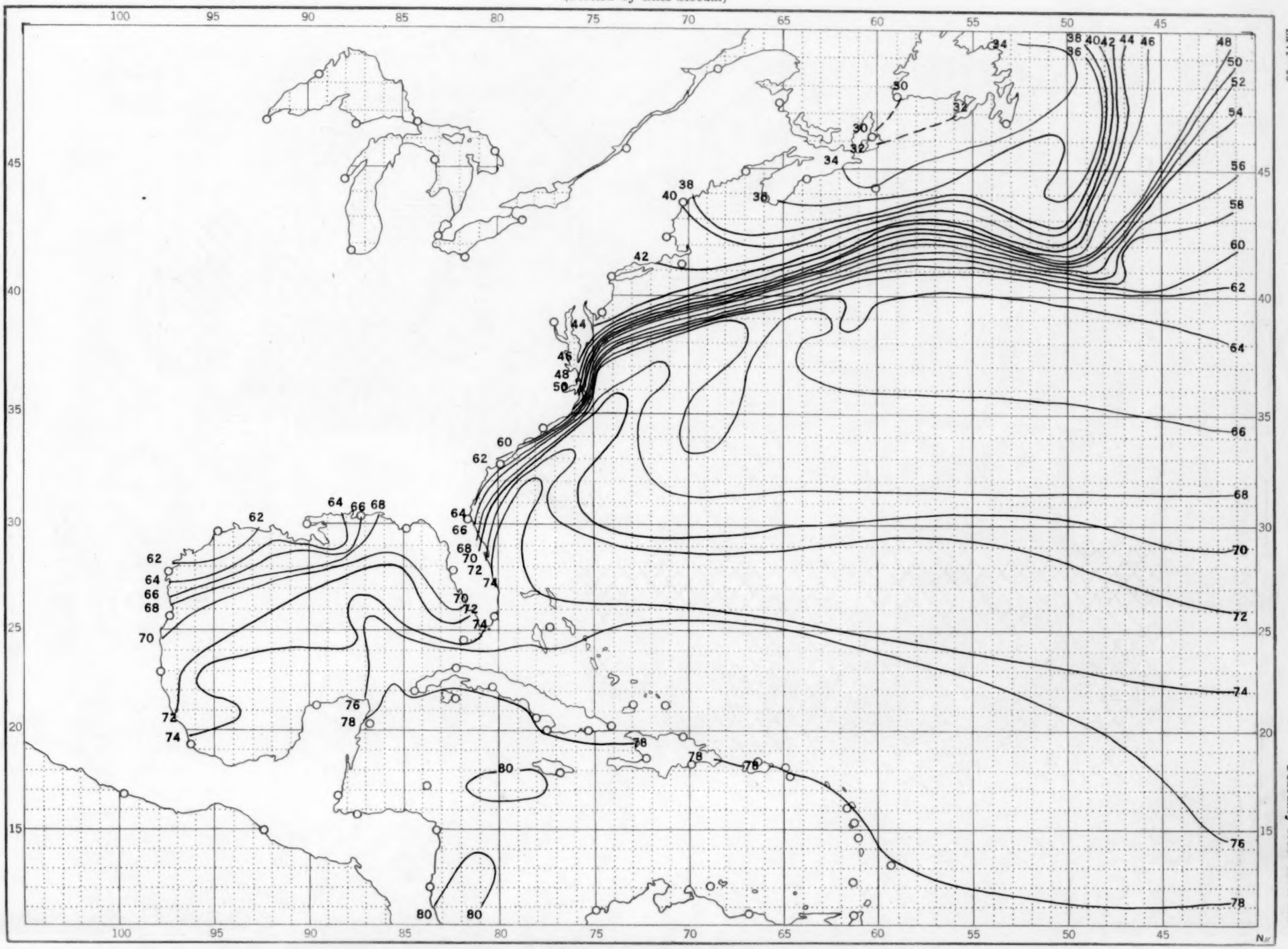


Chart 3. Average Sea-Surface Temperature (°F.) for February 1912-1931

(Plotted by Giles Slocum)

Chart 3. Average Sea-Surface Temperature (°F.) for February 1912-1931

(Plotted by Giles Slocum)

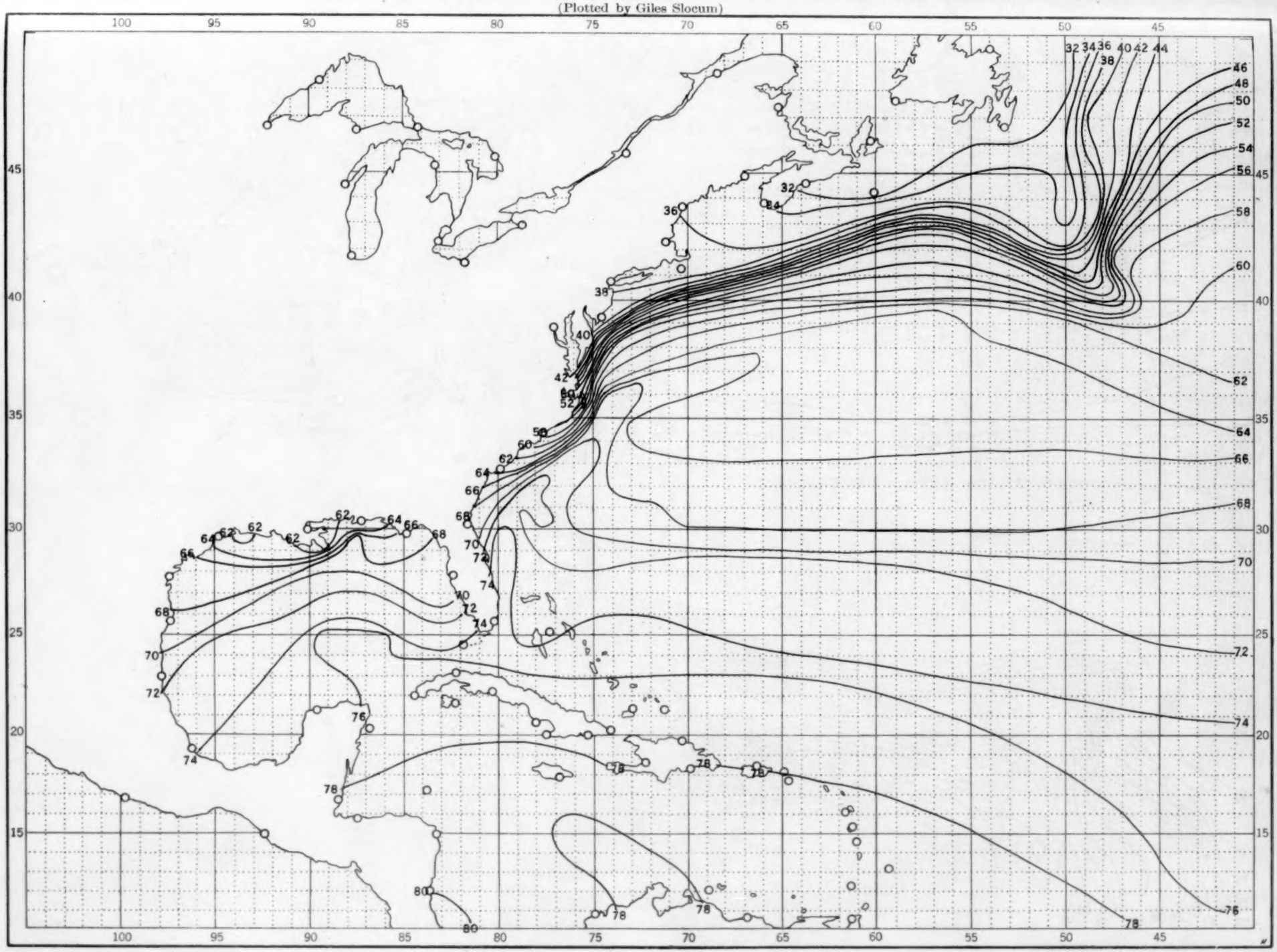


Chart 4. Average Sea-Surface Temperature (°F.) for March 1912-1931

(Plotted by Giles Slocum)

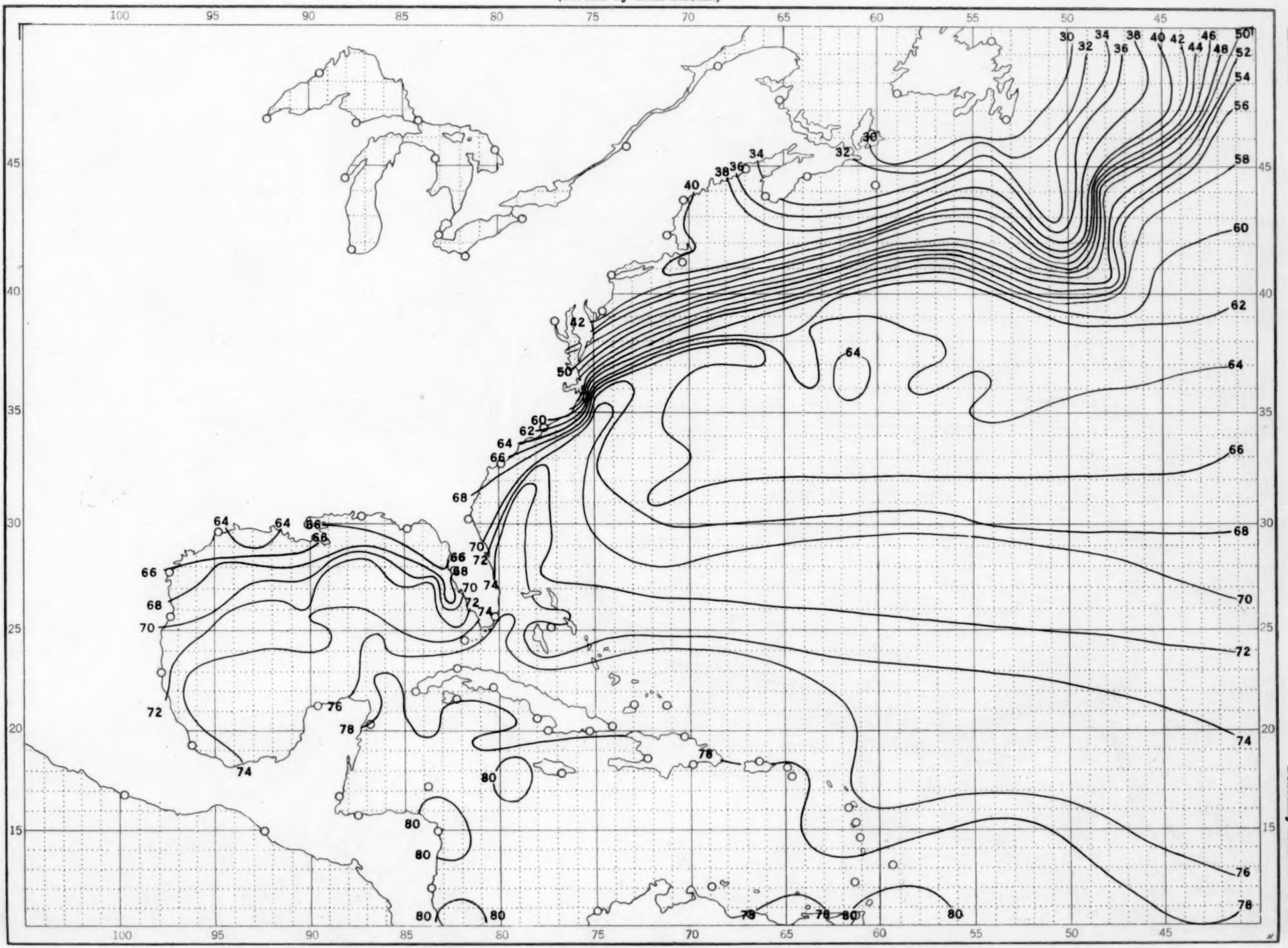


Chart 5. Average Sea-Surface Temperature (°F.) for April 1912-1931

(Plotted by Giles Slocum)

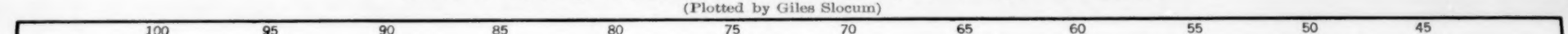


Chart 5. Average Sea-Surface Temperature (°F.) for April 1912-1931

(Plotted by Giles Slocum)

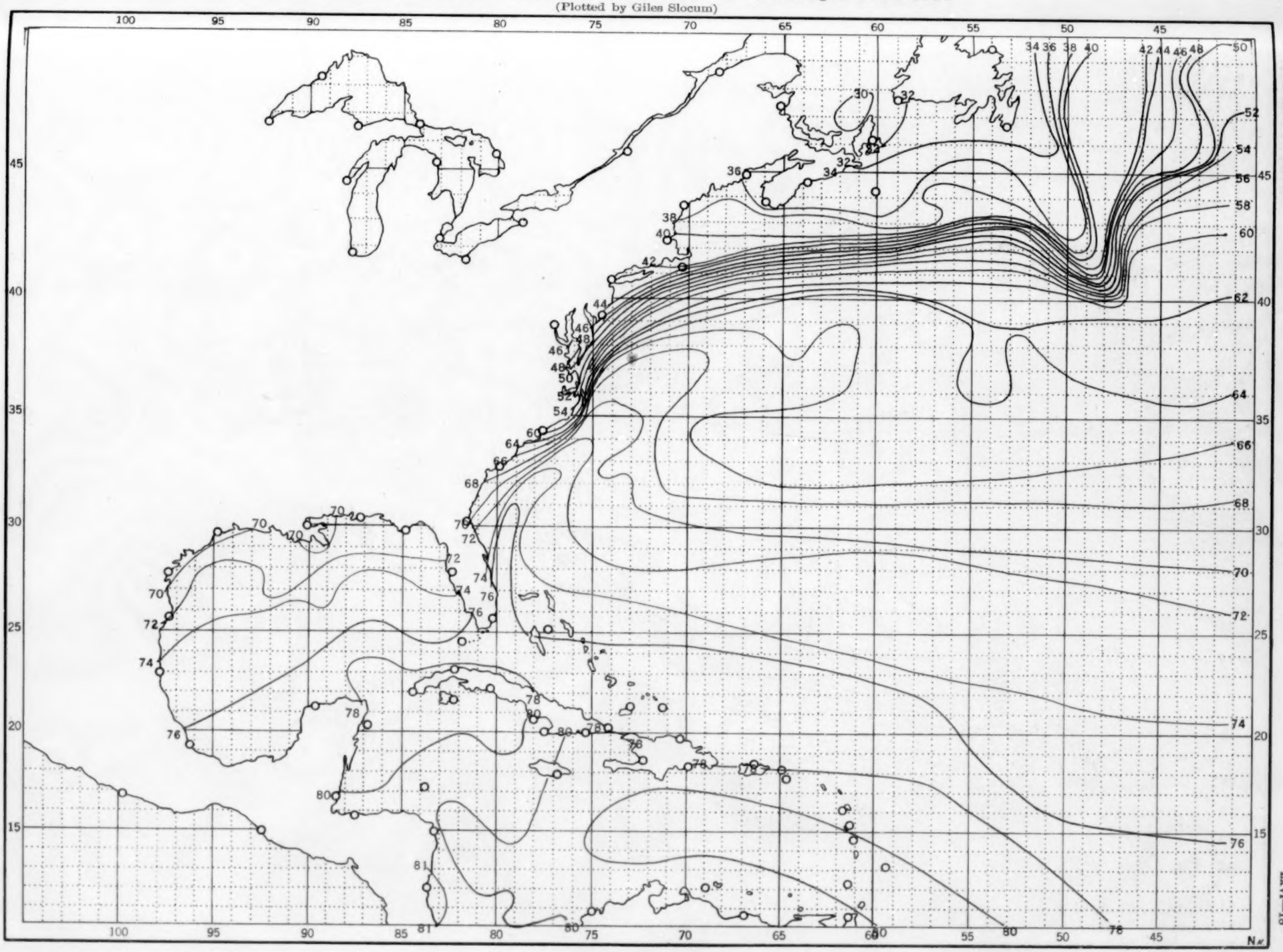


Chart 6. Average Sea-Surface Temperature (°F.) for May 1912-1931

(Plotted by Giles Slocum)

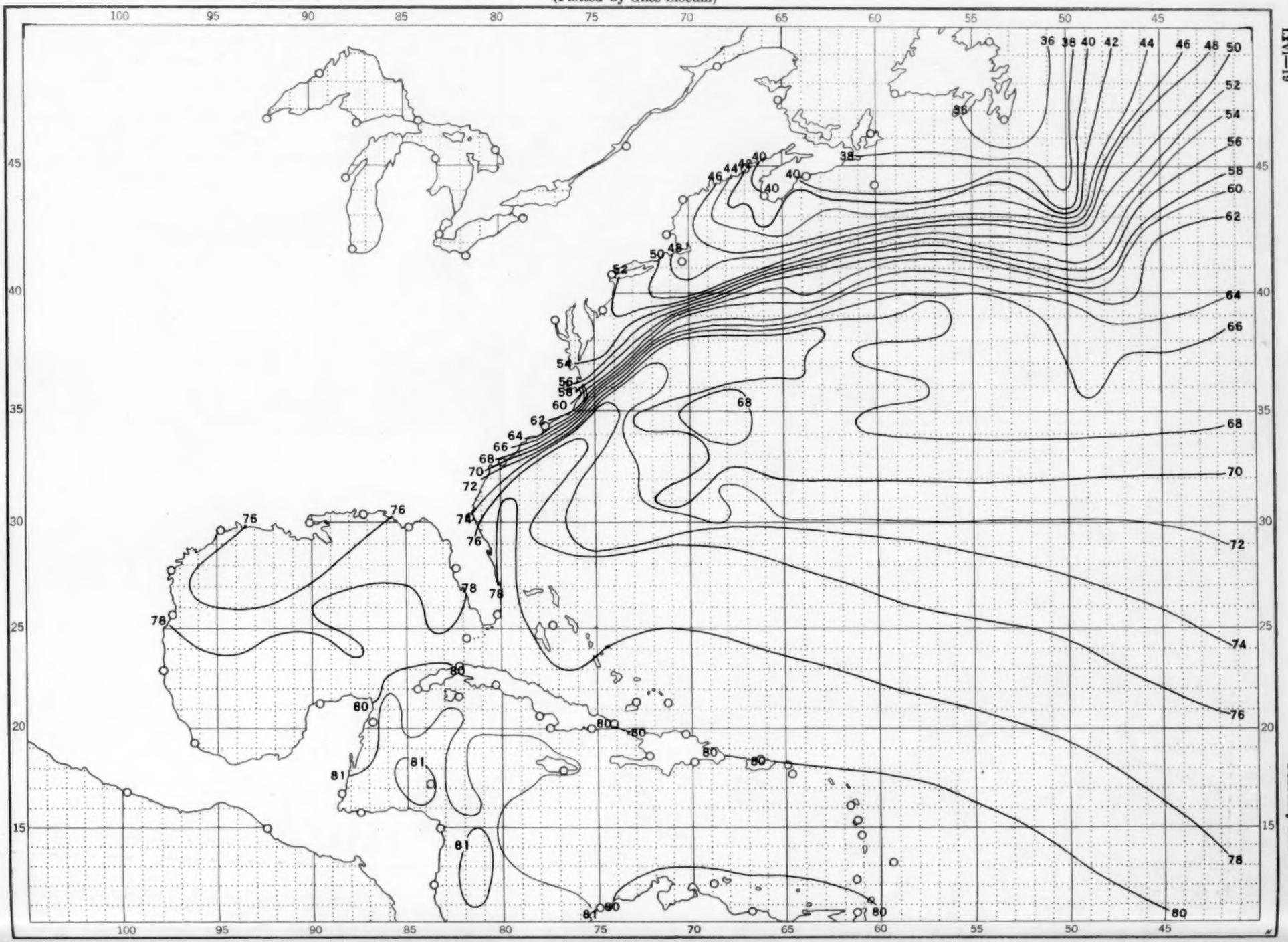


Chart 7. Average Sea-Surface Temperature (°F.) for June 1912-1931

(Plotted by Giles Slocum)

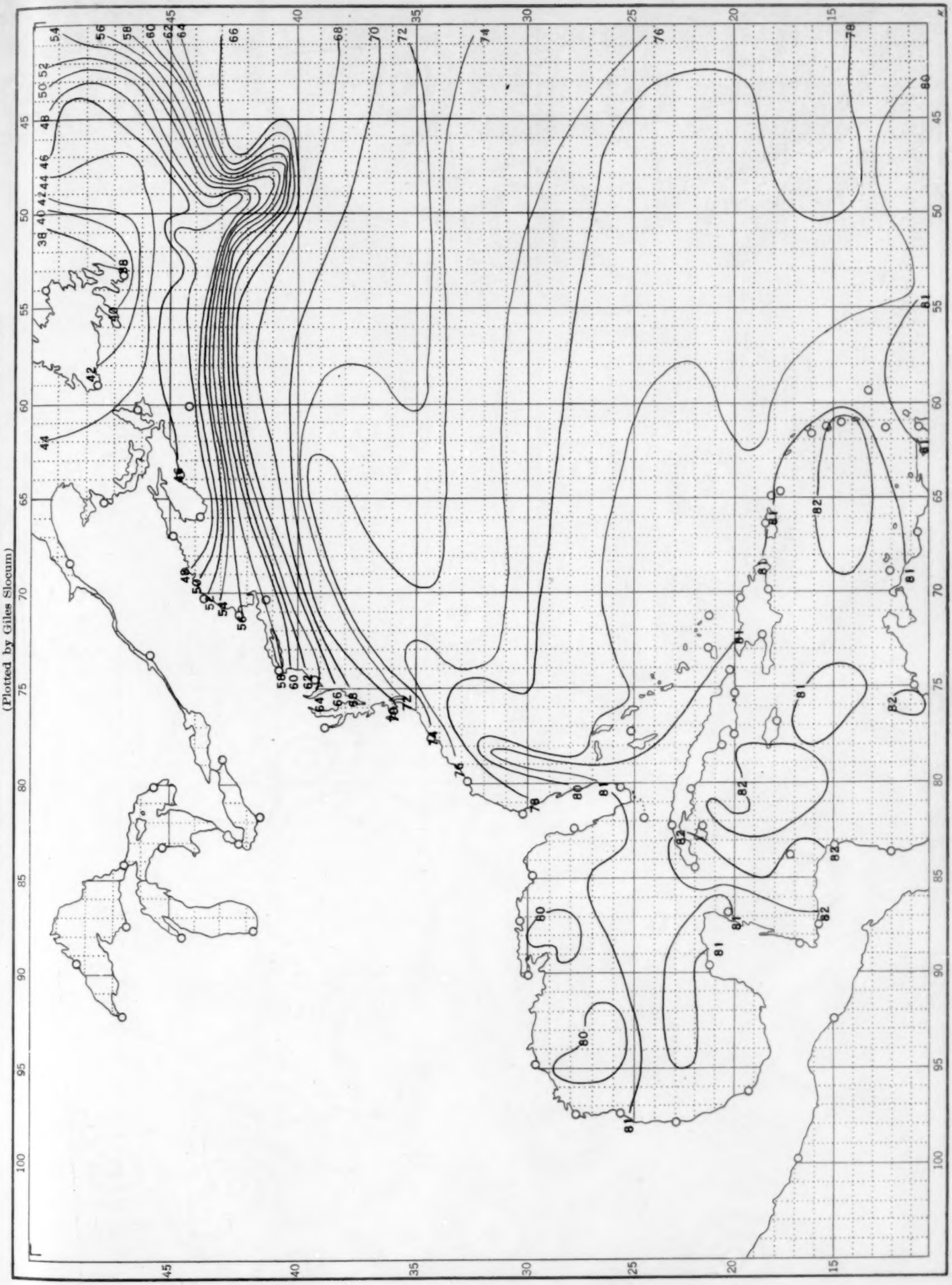


Chart 7. Average Sea-Surface Temperature (°F.) for June 1912-1931
(Plotted by Giles Slocum)

Chart 8. Average Sea-Surface Temperature (°F.) for July 1912-1931

(Plotted by Giles Slocum)

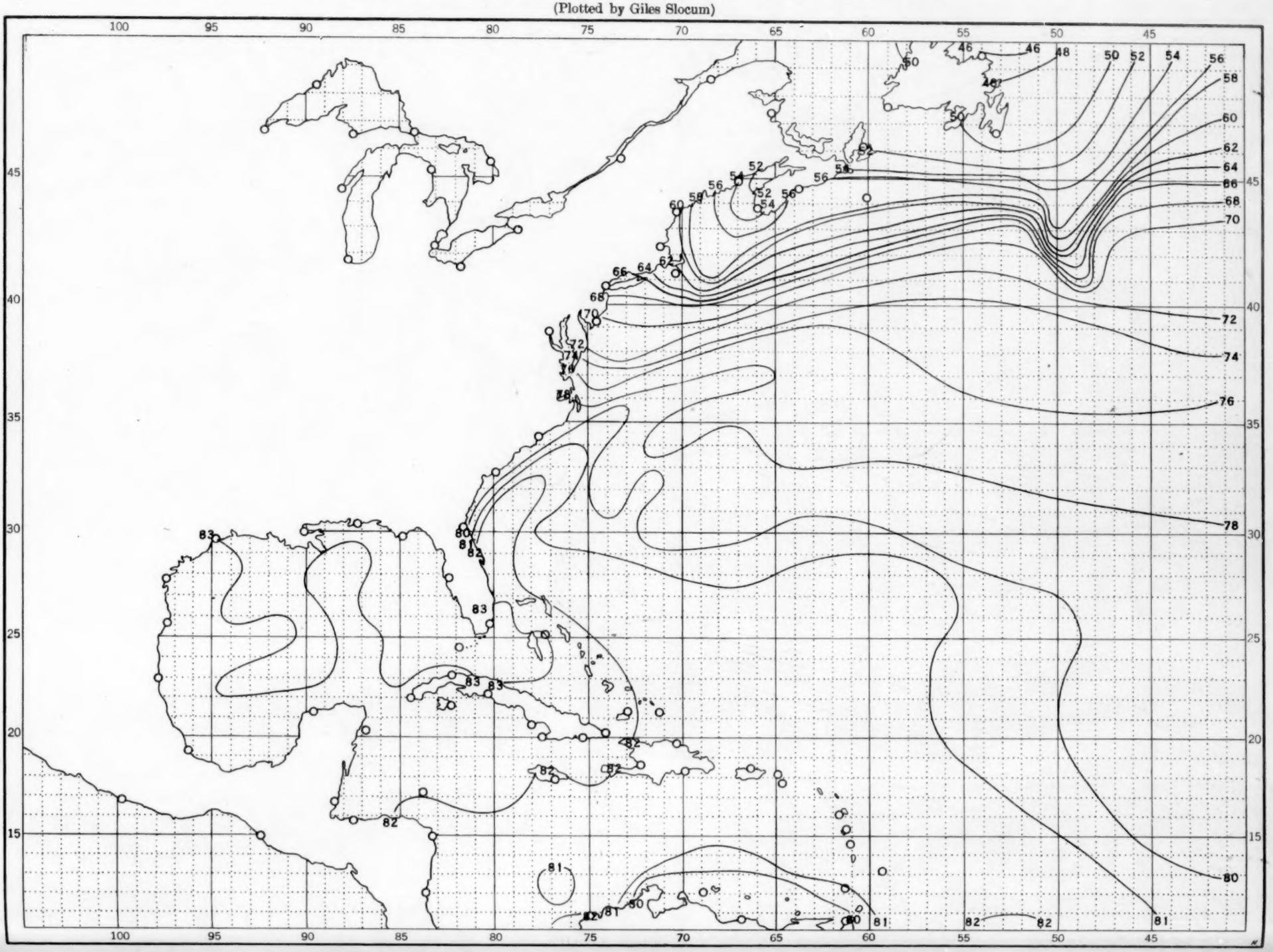


Chart 9. Average Sea-Surface Temperature (°F.) for August 1912-1931

(Plotted by Giles Slocum)

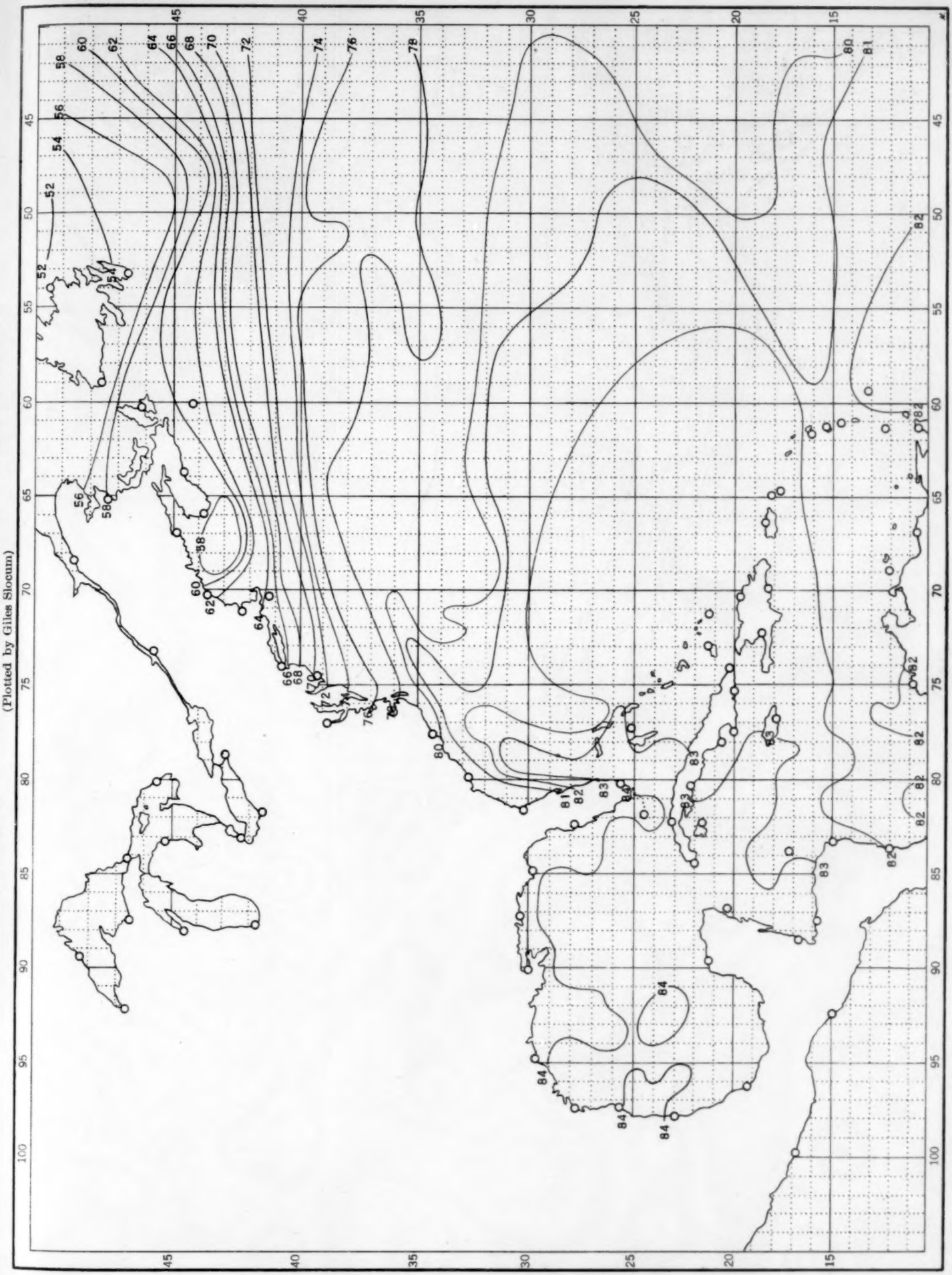


Chart 9. Average Sea-Surface Temperature (°F.) for August 1912-1931
(Plotted by Giles Slocum)

Chart 10. Average Sea-Surface Temperature (°F.) for September 1912-1931

(Plotted by Giles Slocum)

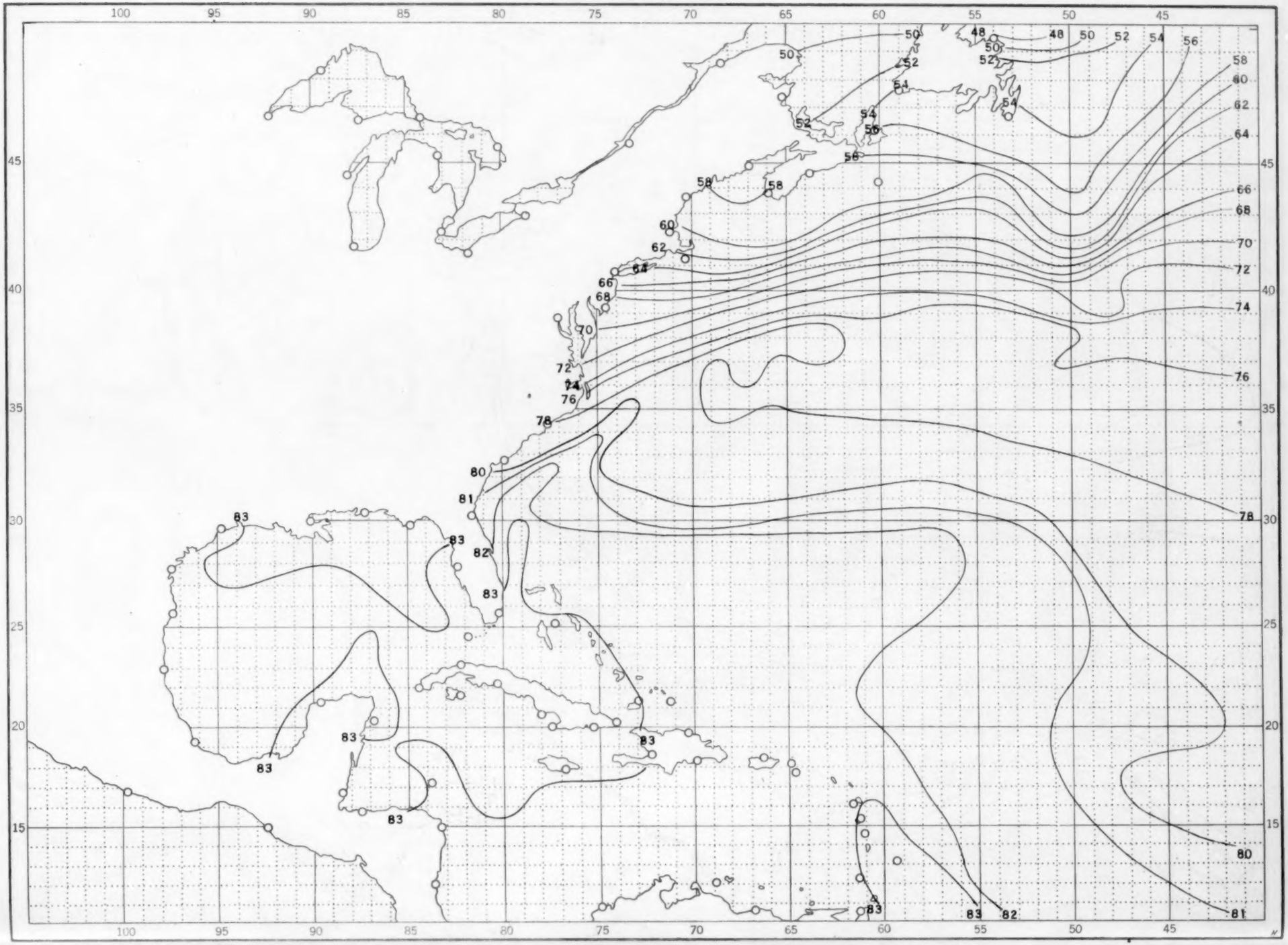


Chart 11. Average Sea-Surface Temperature (°F.) for October 1912-1931

(Plotted by Giles Slocum)

Chart 11. Average Sea-Surface Temperature (°F.) for October 1912-1931
(Plotted by Giles Slocum)

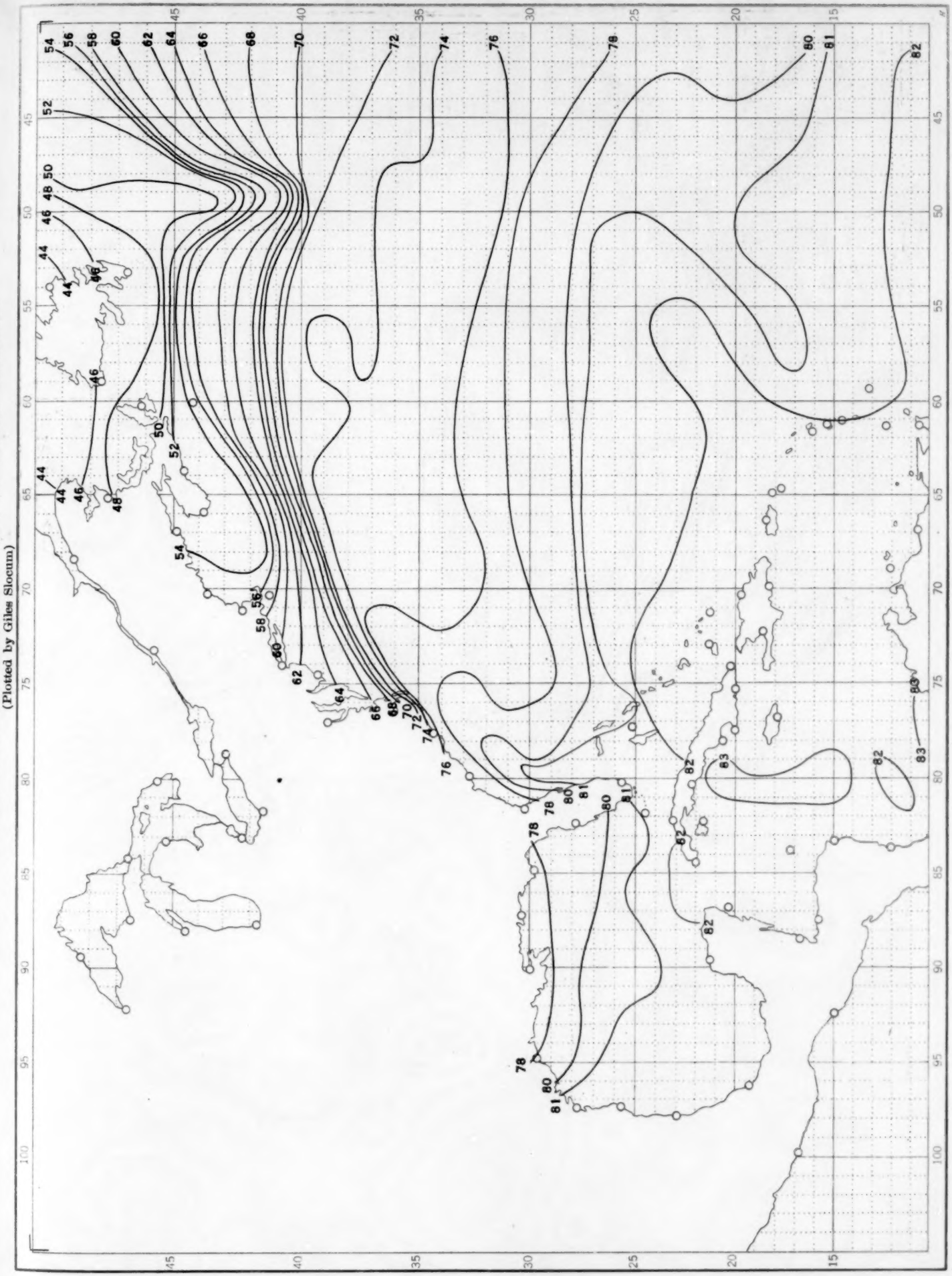


Chart 12. Average Sea-Surface Temperature (°F.) for November 1912-1931

(Plotted by Giles Slocum)

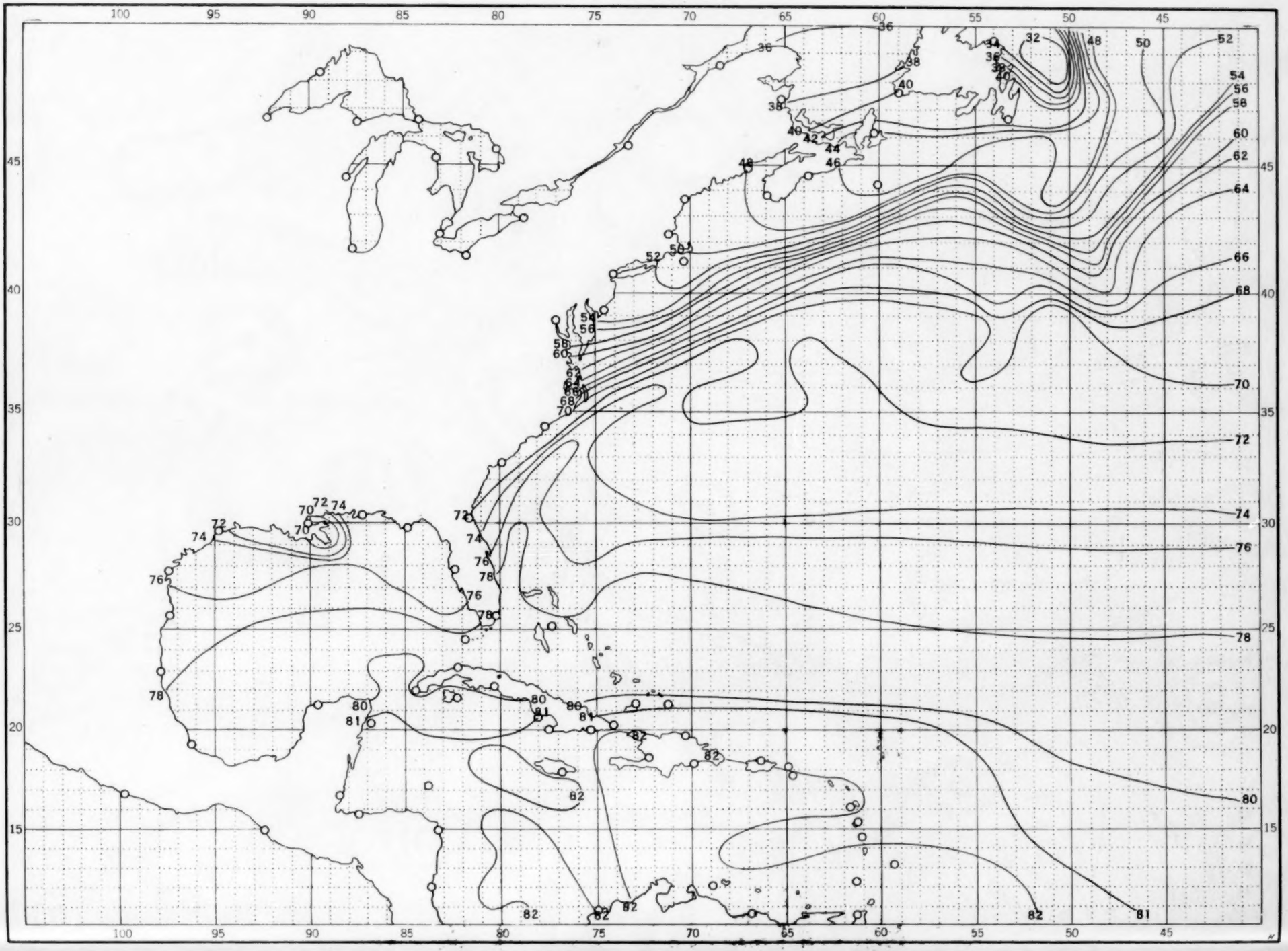


Chart 13. Average Sea-Surface Temperature (°F.) for December 1912-1931

(Plotted by Giles Slocum)

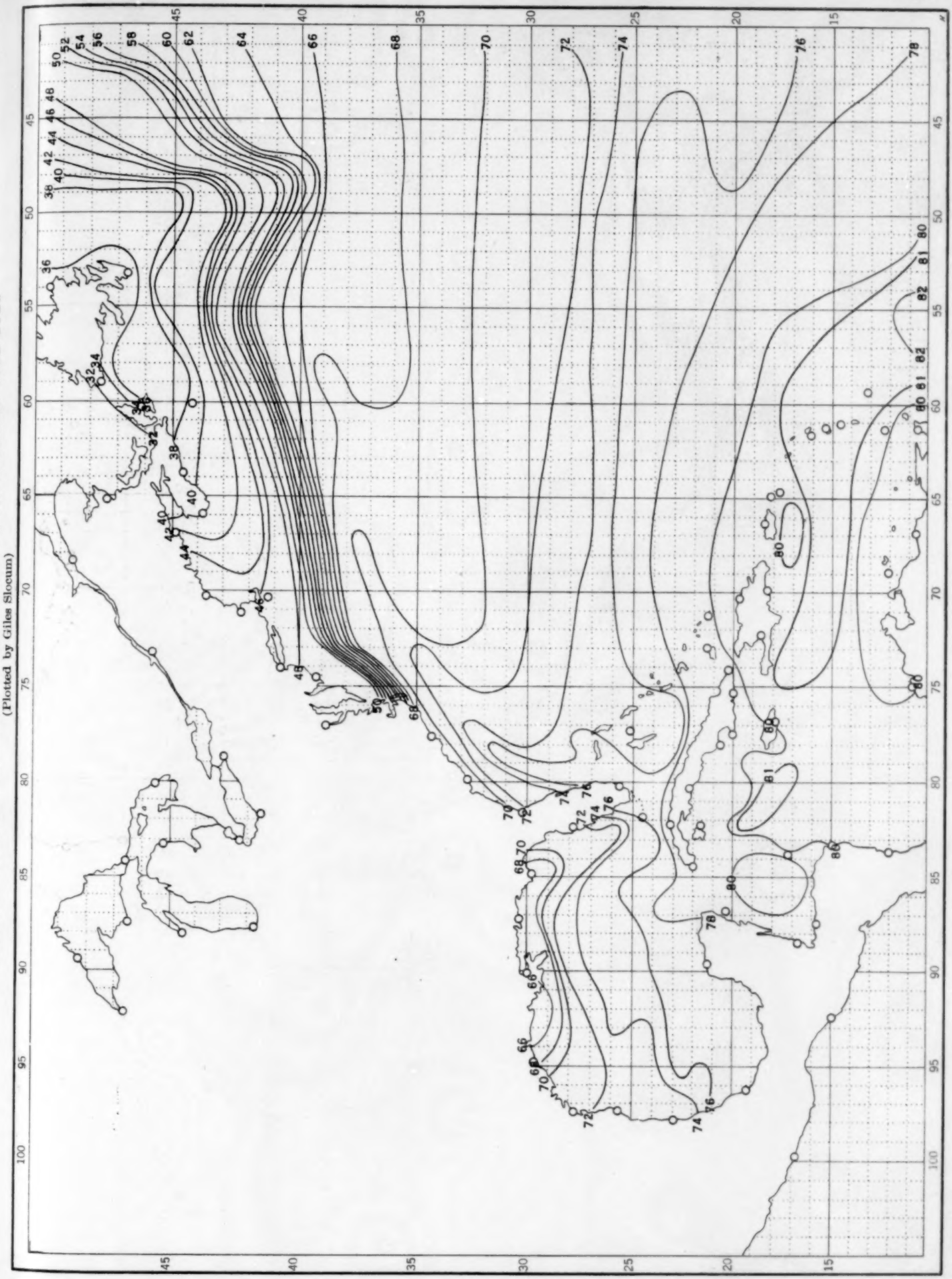


Chart 13. Average Sea-Surface Temperature (°F.) for December 1912-1931
(Plotted by Giles Slocum)

Chart 14. Annual Range of Normal Sea-Surface Temperature

(Plotted by Giles Slocum)

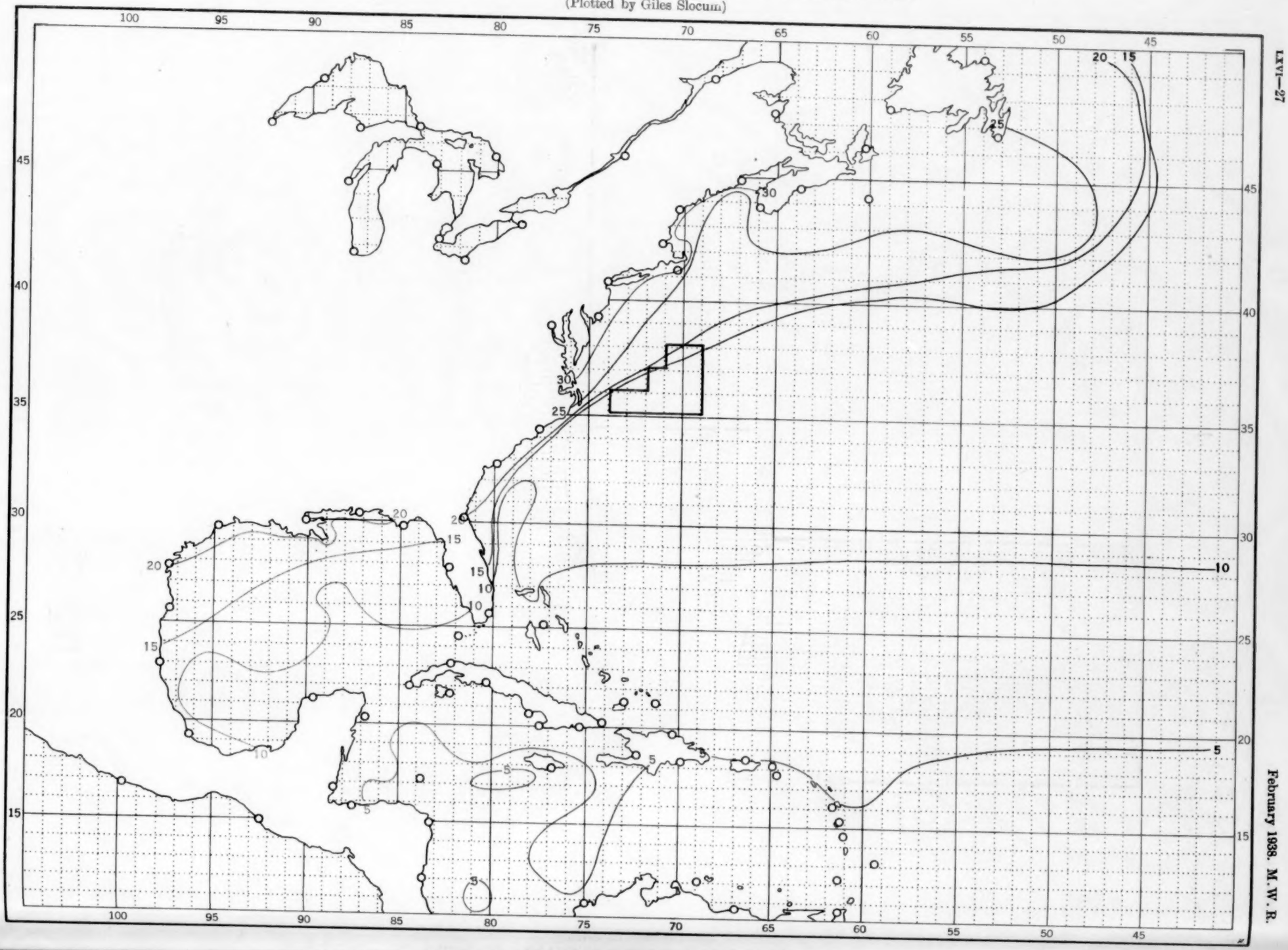


Chart 15. Normally Coolest Month of the Year

(Plotted by Giles Slocum)

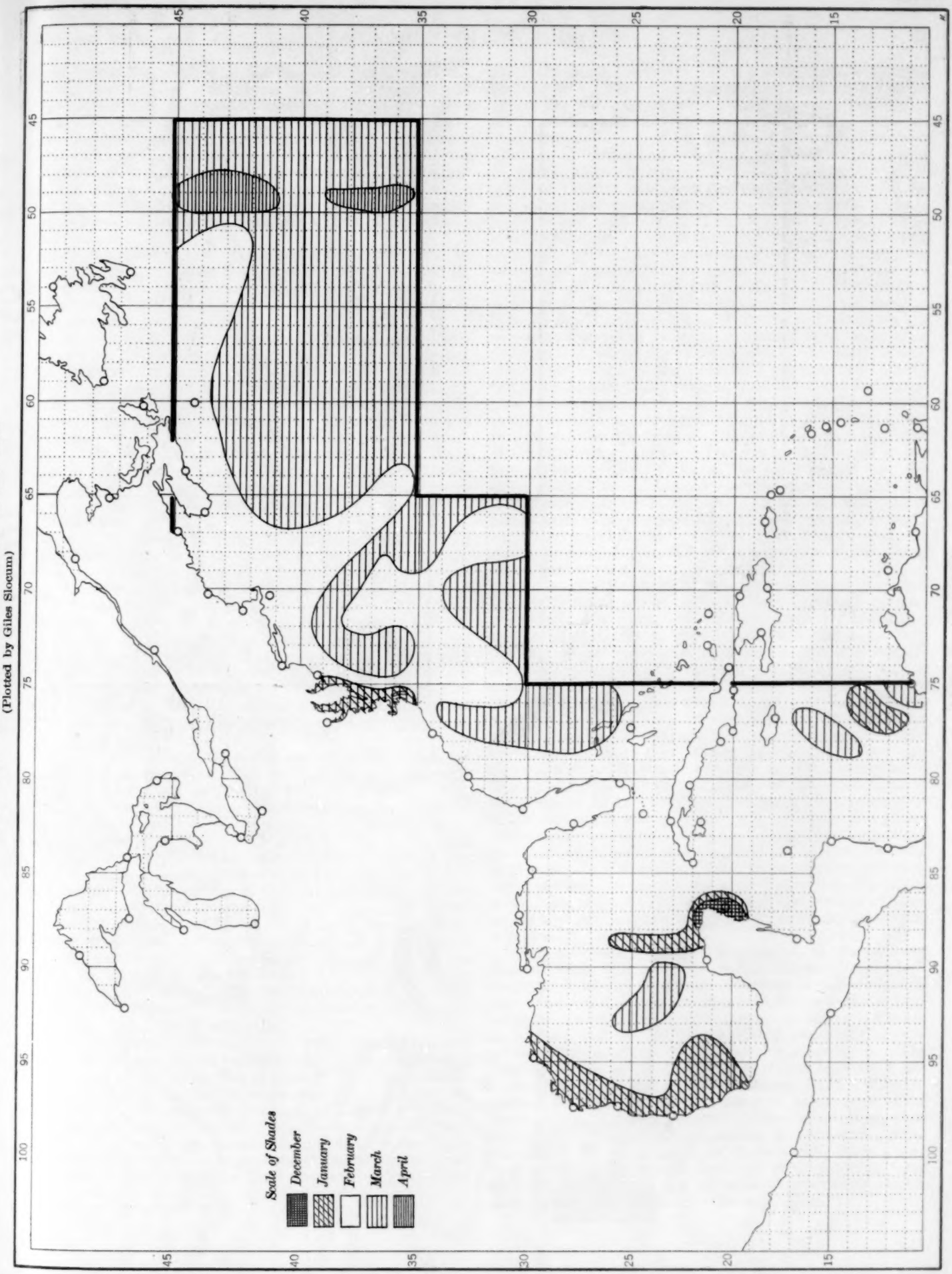
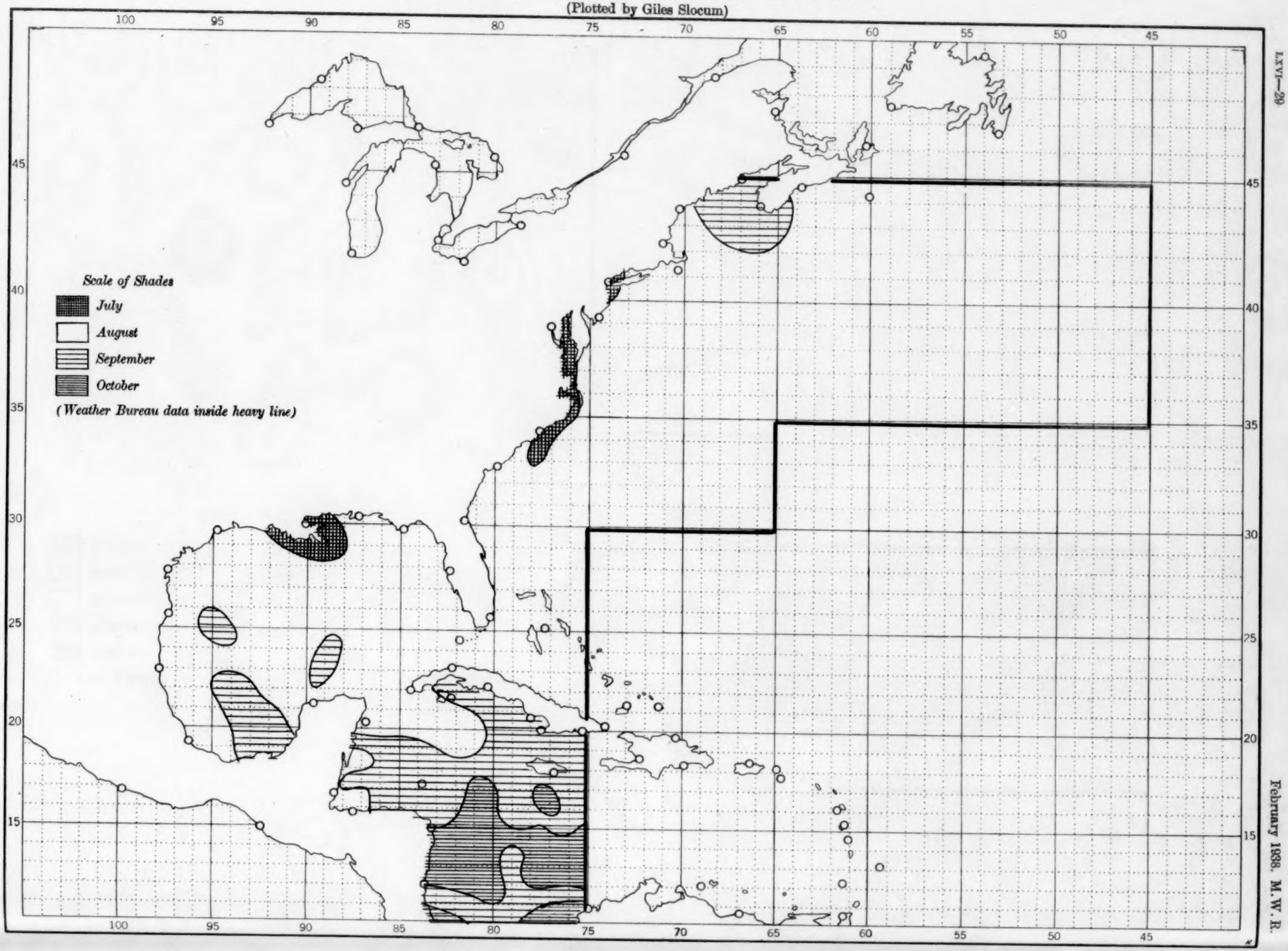


Chart 15. Normally Coolest Month of the Year
(Plotted by Giles Slocum)

Chart 16. Normally Warmest Month of the Year

(Plotted by Giles Slocum)



ered before the opening of the Panama Canal made the Caribbean Sea the well-traveled ocean thoroughfare it now is, and the normals, of necessity, rested on scanty data. Even in the areas where other compilations have used fairly abundant data, the still richer material now available has allowed the use of a small unit of area, the smallest as yet employed for these waters. The ability to use such a small unit of area is particularly valuable for the western North Atlantic Ocean, where temperature gradients are steep, and geographic origins of the surface water diverse.

The data used in the preparation of the charts were, in the main, gathered after the end of the period covered by the British data, making the material here presented conceivably useful for studies of secular trend in water-surface temperatures.

Charts 2 to 13 are the 12 monthly normal charts prepared from the data here discussed. It will be noted that the isotherms drawn on these 12 charts extend beyond the area shown on chart 1. The isotherms were extended [7] to 40° W. by using the British data published in the 1926 issues of the Marine Observer. For this area, from the boundary of the Marine Division area to the 40th meridian, the British data are about as numerous as those now in possession of the United States Weather Bureau in accessible form, and represent a longer period of years than has as yet been made accessible from the Marine Division files.

Chart 14 shows the range in normal temperature of the water surface from the coolest to the warmest month. This chart, like the 12 monthly normal charts, covers the region as far east as 40° W. The remaining charts extend only to the limits shown on chart 1. As chart 14 shows, the range is about 5° F. south of the Tropic of Cancer. It is less than 15° in much of the northern latitudes, but is more than 15° where the Labrador Current brings cold water southward to be warmed by the intense insolation found in middle latitudes in the summer, and is greatest in the area close to the coast, where water temperature variation is dominantly affected by continental air temperature.

In a given locality, the water-surface temperature remains nearly constant during the months from January to April, inclusive, and again from July to October, inclusive. Chart 15 shows the coolest month, which is February over most of the area but is March over much of that portion of the region north of the thirty-fifth parallel. January is cooler than March or April in the Gulf of Mexico, and is warmer than these months in the greater part of the sections of the Caribbean Sea and the North Atlantic Ocean here included. Chart 16 shows the month which is warmest. July is warmest in very limited areas close to the coast. August is the warmest month over most of the ocean surface represented on chart 16, except in the Caribbean Sea. September is warmest in the Caribbean Sea north of about 13° N., and October is warmest in most of the area south of this parallel.

The Gulf Stream surface waters average slightly warmer than the surface waters immediately to the southward, as far east as the sixty-fifth meridian. To the north of the Gulf Stream the temperature gradient is very steep, and the true temperature gradient at any one time is even steeper than the normal gradients shown on charts 2 to 13. As a corollary, the isothermal lines, representing the true water-surface temperature gradient are more irregular at any one time than the normal isotherms, since the northern margin of the Gulf Stream changes position to a slight extent and because there are invasions of warmer water into the cold-water area and possibly of colder water into the warm-water area. The areas of steep temperature gradient may be considered, therefore, as zones of mixing between warm and cold water masses of widely differing temperatures, and consequently, as zones of variable surface water temperature. Similarly, the widely-spaced isothermal lines on the charts indicate areas where variation of surface-water temperature is mainly seasonal in character, and variations are small from day to day, or, in midwinter and midsummer, are small even from month to month.

In winter, even the greatly flattened-out normal temperature gradient, north from the axis of the Gulf Stream, across the width of the Cold Wall, which appears on the charts as a series of very closely-spaced lines, even after the constant wanderings of the axis of the Gulf Stream and of the margin of the Cold Wall are smoothed out by using the normal temperatures, is the steepest horizontal natural temperature gradient of more than strictly local extent, in the world, except for the midwinter air temperature gradient inland from the Gulf of Alaska to the interior of the Alaskan peninsula. There is another steep water-temperature gradient between the Gulf Stream and the coast of the United States during the cooler months, but this gradient is much less abrupt in the summer, and in places even disappears in the warmest months, whereas the steep gradient between the Gulf Stream and the waters to the north exists both summer and winter, being about half as steep in summer as in winter.

In drawing the charts it can be appreciated that certain deliberate inaccuracies have been necessary because of limitations in resolution of detail attainable in drafting and in the printing process. The isotherms have been placed as close together in some places as was physically practicable, and have even been necessarily omitted on some charts, near to Cape Hatteras, because of their excessively crowded configurations, it is probable that in most of these places, where the lines on the charts are crowded the true normal surface-water temperature gradient is much steeper than is shown. Certain other uncertainties also exist which are due to the inadequacies, already discussed, of the data and no claim can be made for accuracy in the detailed placing of the intersections of the isotherms with the coast line. Usually the observations close to the coast are scarce except near important ports, so that harbor temperatures are almost the only data available. Therefore, while some attempt has been made to trend the lines in the correct directions along the coasts, the principal consideration in the placing of their coastward terminations has been to allow room for the temperature figures.

From the meteorologist's standpoint, it would seem that in most cases little essential information is lost, however, from the necessary coarseness of the method of presenting the data. The important fact is that the temperature gradient at the north margin of the Gulf Stream is so steep that it may be considered essentially a temperature discontinuity of considerable magnitude. The position of this north margin may indeed vary by a few dozen miles in the course of months and be in a different position by this distance from one year to the next at the same season, but again, meteorologically speaking, even this meandering is a phenomenon taking place in a comparatively narrow compass. Consequently, there exists, both summer and winter, century after century, what may be treated as a line of water temperature discontinuity always in essentially the same place.

[7] Cf. Marine Observer, Vol. III, op. cit.

An air mass, moving over the water, and attaining a position athwart the Cold Wall, will be profoundly affected in its properties by this water-surface temperature contrast. For example, the frequent and dense fogs so often observed in the environs of the Grand Banks are formed in warm air masses which pass over the southward-jutting tongue of cold surface water originating in the Labrador Current. As an example in the opposite thermal direction, a southward- or southeastward-flowing air current, moving into the area of the Gulf Stream and the warm North Atlantic Ocean waters beyond it, will be subjected to vigorous convectional overturning, with substantial increase of moisture content. The observed effect of such a polar air mass in reducing the temperatures of these warm surface waters seems to indicate that the thermal transfer is of sufficient magnitude to bring the mean temperature of a layer of cold air 2 miles deep from its original value to one in equilibrium with the surface-water temperature, assuming that convection does not extend above this height, that the exposure time be 2 days, and that the upper 10 meters of the water contribute all the added heat.

The heat capacity of the water is much greater, volume for volume, than the capacity of the air, however; and in the Gulf Stream, movement of the water, both horizontally along the surface and vertically through convection, enters as a controlling factor in maintaining water-surface temperature whenever any important cooling takes place. The result is, that even a succession of cold waves reaching the Gulf Stream will not radically modify its surface temperature, nor greatly impair its ability to heat the next cold air-mass reaching it.

An area was chosen off the Virginia-Carolina capes, as a sample, and a temperature history [8] month-by-month, was compiled for this area, the limits of which are outlined on chart 14. This area was chosen so as to exclude all the cool waters shoreward from the Cold Wall, while including an area of warm water all of which would be close to the continent, and therefore, exposed to the influences of continental air masses modified only by littoral, as distinguished from marine, conditions. The axis of the Gulf Stream usually traverses this area, but the northwestern portions of the region normally occupied by this ocean current are not included, since the variations in temperature are here largely due to the alternate occupation of this area by Gulf Stream water and by cold water of the continental slope. The southern and eastern portions of the sample area lie oceanward from the Gulf Stream, and the surface water is slightly cooler in these portions than in the Gulf Stream, the average difference being slightly over 1 Fahrenheit degree. The solid line on figure 1 shows the annual march of the normal temperature for this area, the coldest month being February, with a normal of 65.8°, and the warmest, August, 79.8°. The dotted lines show the temperatures of the extreme warmest and coolest months in 20 years' record for each month of the year. In determining the positions of the dotted lines, however, months with less than 15 observations were not considered. The indicated averages for such months based on such observations as were available when these averages were higher or lower than those selected by this arbitrary criterion of 15 observations as a minimum, are shown by dots, with the year in which they were found shown in the footnote to the figure.

It can be seen that, while the range of possible mean temperature of the surface water in this area is an appreciable fraction of the annual range, it is yet, on an absolute scale, not very important. Since this area was chosen as a sample in which the continental temperature influence would be at a maximum for warm-water areas within the region covered by the charts, we may conclude that the seasonal normal temperature of the surface water in a given portion of the western North Atlantic Ocean is a good measure of the actual temperature in that portion at any given time.

It could be wished that more accurate data be made available, but greater precision than that afforded by the monthly normal can only be obtained by overcoming formidable difficulties, which would be further multiplied if the day-by-day surface water temperature situation should be required on the same day in which the observations be made. It is believed, therefore, that the monthly normal conditions, as shown on the accompanying set of 12 charts, constitute as close an approach to the synoptic condition as it is at present practicable to reach, and that these charts can be used with nearly as much confidence, as a partial basis for daily forecasting purposes, as could the most ideally adequate synoptic charts of water-surface temperatures for this region.

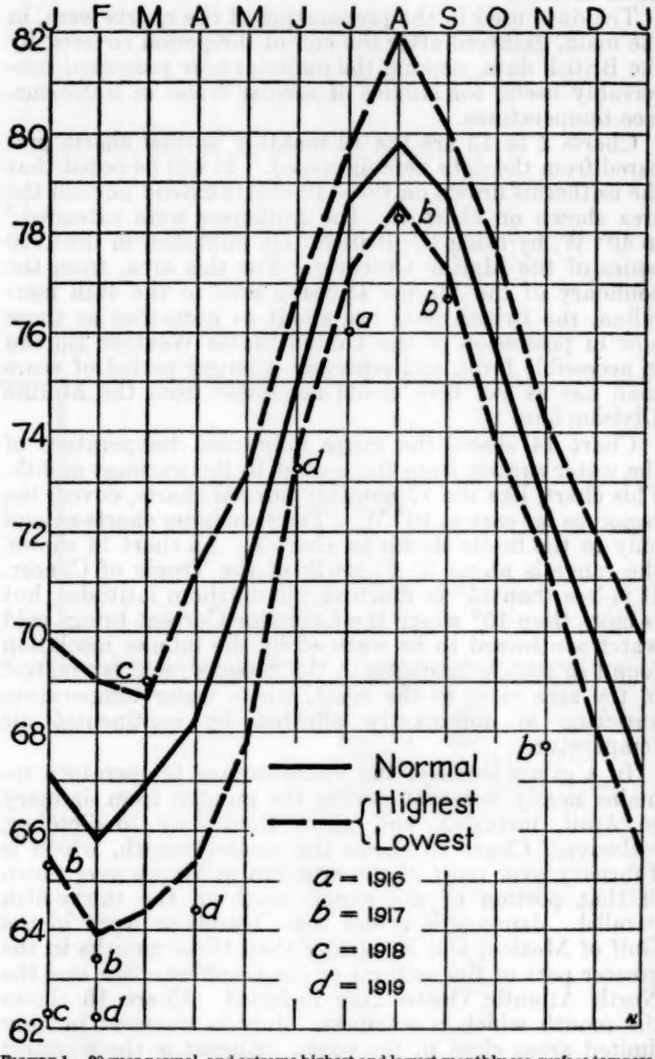


FIGURE 1.—20-year normal, and extreme highest and lowest monthly sea-surface temperatures for an area off the Virginia-Carolina capes (°F.)

It would perhaps be worth while, however, to obtain a

[8] This temperature history may be found in MONTHLY WEATHER REVIEW, vol. 65, p. 461, December 1937.

much larger number of observations from the waters within a degree or two of the coast of the United States and outside the areas covered by the convergence of important steamer lanes. Such an increased number of offshore water-temperature observations would be useful, since the majority of inquiries concerning water-surface temperatures which come to the Weather Bureau from outside the professional meteorological and oceanographic circles, are for temperatures largely within these coastal waters, for which, as shown on chart 1, the Marine Division has fewest observations available per 1° square. In one case, for example, an inquirer asked the Weather Bureau to furnish the average temperature departures from normal for each of several days in an area of less than a degree in extent. The Marine Division receives about one observation a year from this particular small area, while at least 10 observations a day would be needed to compute even the probable sign of a departure from normal for each of a succession of days. This would be about 4,000 times as many observations per year for the area as are now available.

The making of requests far beyond the existing limitations of the number of available observations and the capacity of the Marine Division personnel is not confined, however, entirely to the nonprofessional inquirer. An eminent scientist outside the Weather Bureau, at one time requested that the water-surface temperatures for each five-mile zone of distance from land be separately classified in the Marine Division tabulations of nearshore water temperatures, for two areas, one of which is indicated on chart 1 as an area from which the Weather Bureau cannot depend on as many as one observation a month for even a strip 70 miles wide and 70 miles long.

The Marine Division answers such inquiries to the best of its ability, and an attempt is made to supply all feasibly available information. Many of the requests for information, even some with which it is impossible to comply because of limited facilities and personnel, are entirely reasonable. A large class of these inquiries can be answered, in part at least, and for the first time by the present set of charts. It is hoped that these charts will therefore prove helpful not only to the forecasters for whom they were primarily intended, but also to the casual, but serious-minded student of meteorology or oceanography as well.

NOTES AND REVIEWS

The Effect of the Magnetic Storm, January 22–26, 1938, on Telegraphic Transmission.[1] By CHARLES M. LENNAHAN. On January 22, 1938, the reception of telegraphic signals of the regular 7:30 a. m., eastern standard time, weather observations was seriously delayed at the San Francisco district forecast center. It was not until 12:23 p. m., eastern standard time, that the final sheet of signals was received. This unusual situation was the result of interference in telegraphic transmission caused by one of the severe magnetic storms accompanying the present period of maximum sunspot activity; brilliant auroral displays were also observed, especially on January 26.

The interference in telegraphic transmission was most pronounced on the transcontinental lines; it began on January 22 and increased in intensity until the afternoon of January 25, at which time the potential induced in the transmission lines was occasionally in excess of 400 volts in many parts of the country. When these foreign potentials exceeded the potentials regularly used on the telegraph circuits, operation had to be suspended. A similar situation existed on the ocean cable circuits. The surges of electricity induced by the storm seldom lasted more than 10 minutes, but the frequency with which the surges occurred and the rate at which the potential increased from zero to a maximum were the greatest ever experienced. However, the telegraph lines were not affected as much as during previous years because of improved methods recently developed and inaugurated to combat such interference.

After the maximum interference was reached on January 25, conditions improved rapidly and the circuits were back to normal on the afternoon of January 26.

Auroras of January 21–22 and 25–26, 1938. By WILLIS E. HURD. At 2:27 a. m. of January 22, 1938, Second Officer Flint, of the American steamer *Coast Merchant*, bound from Tacoma to Bellingham, Wash., observed what he termed "a very unusual display of Aurora Borealis." The ship was then off Alki Point. Fifteen minutes after the first reddish auroral glow was seen, the entire northern half of the sky was alight with beams of various colors that extended toward the zenith, while in the southern sky the streamers were mostly white. The display, with irregular but generally diminishing intensity, lasted until daylight.

During the night of the 21st–22d, the phenomenon of the Northern Lights was visible over much of the western part of the United States, accompanied by magnetic disturbances. At Roswell, N. Mex., on the 21st, it was reported by the Weather Bureau as being the first known occurrence of the character in that vicinity, and at San Diego, Calif., on the morning of the 22d, as the third of record there. It was seen at least as far to the eastward in the United States as Lacrosse, Wis., on the 22d; and was in addition reported near 30½° N., 75° W., by the American steamer *Chilore*, in the North Atlantic.

The auroral display of January 25–26 was even more magnificent and widespread, but was especially pronounced over Europe, the North Atlantic Ocean, and the eastern part of the United States and Canada. Isolated reports from the Weather Bureau Offices at Huron, S. Dak., and Madison, Wis., show that it was also seen faintly in localities to the westward.

The phenomenon, where seen in richest form and coloring, was observed from about 6:30 p. m. (local) of the 25th until approximately 1 a. m. of the 26th. This aurora, according to E. W. Barlow, in The Meteorological Magazine (London) for February 1938 "was accompanied by a great magnetic storm." In parts of the northeastern United States there was some interruption to telegraphic communications.

According to Nature (London) in its issue of February 8, 1938 (vol. 141, pp. 232–235): "Three periods of brilliant display were noted, around 7:45, 8:30, and 9:45. The main features noted were red glows in the northwest and northeast, with a low green arc between during the early stages, green and white rays traversing a bright red glow in the north-northeast about 7:45, and rapidly fluctuating green streamers between northwest and northeast about 9:45."

In the eastern United States, as well as on the North Atlantic Ocean, the predominant color was a pinkish to dull red, but often with light beams cast against the ruddy background. At Providence, R. I., the aurora was extremely vivid from sunset until 7:45 p. m., with great

[1] This note is based on information supplied by Maj. E. H Bowie, Official in Charge, Weather Bureau Office, San Francisco, Calif., and by J. C. Willever, first vice president of the Western Union Telegraph Company.

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arches of crimson light and radiations from an auroral crown near the zenith. Here it was noted as being the most brilliant display since March 22, 1920. At Norfolk, Va., there were small patches of red light; and at Augusta and Savannah, Ga., faint pink to darker red glows.

A number of ships reporting to the Weather Bureau or to the Hydrographic Office, indicate the wide extent of the phenomenon as witnessed on the North Atlantic. Some sections of the ocean were heavily clouded, which prohibited a view, while others were partly clouded to clear. In partly obscured areas the spectacle was enhanced by comparison with cumulonimbus or other dark clouds.

A tentative charting of ships' auroral observations for the Atlantic covers the region extending from near the west coast of Portugal west-southwestward nearly to Bermuda and farther southward and westward almost to the Bahamas. The most southerly observation found is that reported by Third Officer W. Chapman, of the British motorship *Northern Prince*, New York to Rio Janeiro. While, in his special report, this observer did not give the ship's position on the evening of the 25th, yet the local noon positions given for the 25th (27°13′ N., 58°37′ W.) and 26th (22°13′ N., 53°51′ W.) indicate that the 2 hours' auroral display was seen on ship at approximately the twenty-fifth parallel. Almost as far south, but much farther to the eastward, in 29°20′ N., 31°47′ W., the phenomenon was reported by the French steamer *Commissaire Ramel*. The westernmost Atlantic observations of the aurora was received by the Hydrographic Office from the Greek steamer *Adamas* and the Dutch steamer *Nederland*. Both ships on the evening of the 25th were in or within a few minutes of 27° N., 71°10′ to 71°57′ W. Third Officer A. Bijl, of the *Nederland*, reported a remarkably red sky extending to an altitude of 35°.

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[RICHMOND T. ZOCH, *in Charge of Library*]

By AMY D. PUTNAM

RECENT ADDITIONS

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, JANUARY 1938

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison. Measurements of the intensity of direct solar radiation through Schott color filters, for the determination of atmospheric turbidity and precipitable water vapor, are conducted at Washington and Blue Hill.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording Eppley thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian Silver Disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (seventy-fifth meridian time) and at noon (local mean solar time).

During February 1938 direct solar radiation intensities averaged above normal at all four stations: Washington, Madison, Lincoln, and Blue Hill.

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of an Eppley pyrheliometer recording on either a microammeter or a potentiometer.

During February 1938 all stations show a deficiency in the total solar and sky radiation for the month with the exception of Fairbanks, New Orleans, San Juan, and Friday Harbor. These four stations also had an excess of total radiation during January.

For the determination of atmospheric turbidity and precipitable water, the intensity of direct solar radiation at normal incidence is measured, with and without color filters, by a thermopile recording on a potentiometer. The publication of table 3 is temporarily suspended, during a reinvestigation of the transmission of the filters.

No polarization measurements were made at Madison due to continual snow and ice cover, nor at Washington since the recently repaired polarimeter has not yet been installed.

TABLE 1.—*Solar radiation intensities during February 1938*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Feb. 1	1.60			0.98	1.21		1.27	1.10			1.32
Feb. 4	5.36				1.16						4.57
Feb. 8	3.45	0.85	0.98	1.14	1.32						2.49
Feb. 10	6.02		.72	.89	1.10		1.12				3.81
Feb. 16	1.68				1.32		1.26				1.37
Feb. 21	2.62			1.08				1.09			3.00
Feb. 25	2.26				1.24						1.68
Means		(.85)	(.85)	1.02	1.22		1.22	(1.10)			
Departures		+.13	+.02	+.01	+.02		+.01	+.09			

MADISON, WIS.

Feb. 14	1.52	0.98	1.11	1.28	1.47						1.07
Feb. 28	1.60	1.11	1.20	1.32	1.48						2.16
Means		(1.04)	(1.16)	(1.30)	(1.48)						
Departures		+.11	+.09	+.10	+.11						

LINCOLN, NEBR.

Feb. 3	1.78		0.91	1.11							1.78
Feb. 5	4.95						1.32	1.19	1.03		8.48
Feb. 6	4.17	1.07	1.18	1.31	1.48		1.46	1.28	1.15	1.05	3.99
Feb. 9	2.87						1.33	1.17	1.01	.89	1.78
Feb. 12	6.50								.97	.83	10.59
Feb. 14	1.37	1.04	1.12	1.24	1.39						1.24
Feb. 18	.74		1.12	1.26	1.43						.91
Feb. 19	.79	1.04	1.15	1.29	1.47		1.51	1.35	1.21	1.10	1.52
Feb. 22	2.87						1.25	1.16			2.87
Feb. 23	2.16						1.26	1.12	.91	.77	1.96
Feb. 25	2.87				1.37				1.01		3.81
Feb. 26	4.37	1.02	1.12	1.25	1.43		1.43	1.28	1.15	1.03	4.75
Means		1.04	1.10	1.24	1.43		1.37	1.22	1.06	.97	
Departures		+.11	+.08	+.08	+.07		+.02	+.07	+.05	+.06	

BLUE HILL, MASS

Feb. 1	1.8				1.41		1.45	1.32	1.19	1.08	1.6
Feb. 8	1.4			1.13	1.43						1.4
Feb. 10	2.8				1.40		1.40	1.16	.96		1.3
Feb. 11	.8				1.40		1.40				1.7
Feb. 12	1.3			1.05	1.30						1.0
Feb. 15	1.5				1.35		1.44				1.2
Feb. 16	1.0			1.37	1.41		1.41	1.26	1.00	.96	.8
Feb. 17	1.4			1.12	1.40						2.2
Feb. 21	1.5				1.32						1.8
Feb. 22	2.4				1.22						1.8
Feb. 26	2.1						1.30	1.11	.95		2.1
Means				1.17	1.36		1.40	1.21	1.02	(1.02)	
Departures				+.09	+.08		+.13	+.05	−.04	+.01	

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
	Gram-calories per square centimeter																
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 29	191	120	225	93	156	176	55	103	258	267	257	187	170	491	98	103	219
Feb. 5	213	95	193	96	177	230	94	138	257	290	296	246	233	507	117	124	232
Feb. 12	210	134	208	120	176	247	139	181	293	323	280	281	238	576	135	106	268
Feb. 19	150	182	320	96	140	352	90	225	438	314	308	410	179	548	197	178	207
	Departures of daily totals from normals																
Jan. 29	−12	−65	+1	−25	+2	−22	+10	−88	−72	−67	+41	−58	−54	+18	+2	−62	.....
Feb. 5	+2	−108	−67	−39	+13	−36	+34	−71	−11	−51	+68	−26	−10	−12	+2	−54	.....
Feb. 12	−11	−88	−61	−21	+6	−41	+57	−92	+7	−21	+33	−9	+10	+18	+3	−46	.....
Feb. 19	−103	−69	+21	−81	−54	+13	−23	−26	+24	−49	+26	+71	−90	−19	+54	−34	.....
	Accumulated departures since Jan. 1																
	−1,624	−3,255	−1,155	−1,358	−196	−1,267	+777	−3,115	+56	−1,253	+553	+70	−798	+950	+455	−1,561	.....

Summary of meteorological conditions during solar observations, Blue Hill, February 1938

Date	Time from local noon	Temperature (° C.)	Vapor pressure (mm)	Wind (Beaufort)	Visibility (0–10)	Sky blue	Cloudiness and remarks
Feb. 1	2:03 a. m.	−8.4	1.8	NW 4	9	8	2 Cu, Light haze. Cloud amt. varying 2–4.
1	0:13 a. m.	−8.2	1.6	NW 4	9	9	3 Cu, Light haze. Edge of Cu nearing sun at end of observation.
8	3:32 a. m.	−8.4	1.4	NNW 4	9	9	Zero clouds. Light haze; light smoke haze N.
8	2:14 a. m.	−5.9	1.5	NNW 4	10	14	Trace Ci, light smoke haze to N.
8[1]	1:56 a. m.	−5.9	1.5	NW 2	10	14	1 Ci, moderate smoke haze to N.
8	0:07 p. m.	−2.5	1.4	NW 1	10	12	4 Ci, light smoke haze to N and NE.
8	2:27 p. m.	−.8	1.1	NW 1	10	8	5 Ci, Cs. Moderate smoke haze to N.
8[1]	2:44 p. m.	0	1.9	NW 1	10	5	Do.
10	3:43 a. m.	.8	2.3	NW 9	10	10	1 Cu, Sc.
10	0:47 a. m.	1.1	2.2	NW 8	10	12	1 Cu.
10	0:04 p. m.	1.1	1.3	N 8	10	11	Trade Cu.
10	2:16 p. m.	1.7	1.5	NNW 6	10	13	Trace Sc.
10	4:02 p. m.	.6	1.1	NW 5	10	12	Trace Cs.
11	3:05 a. m.	−12.2	1.0	NW 4	9	10	8 Ci, few thin Ci passed over sun during screening.
11	0:11 p. m.	−7.1	1.4	NNW 2	9	11	2 Ci, Dense haze to N, light haze to E.
12	3:42 a. m.	−4.9	1.0	Calm	7	10	Trace Ac.
12[1]	9:45 a. m.	−3.7	1.4	S 2	8	14	Do.
12	1:54 a. m.	−3.1	1.4	SSW 2	8	14	Trace Ac, Dense smoke haze N, light to S and W.
15	2:31 a. m.	−9.4	1.7	NNW 5	9−	7	Trace Cu, Sc. Light haze N Sc. and E.
15	0:06 p. m.	−6.7	1.2	NNW 5	10	12	Trace Ci, Cu, light haze N and E.
15	2:11 p. m.	−4.8	1.5	NW 5	10−	11	4 Ci, Cu, Frcu.
16	3:43 a. m.	−13.2	1.0	WNW 5	8	14	Zero clouds. Light haze E, S, W. Dense smoke haze to N.
16	1:58 a. m.	−11.9	1.2	NW 5	9	13	Zero clouds.
16	0:04 p. m.	−8.3	.8	NNW 5	10−	13	Do.
16	2:17 p. m.	−5.6	1.3	NNW 5	10−	10	Do.
16	4:05 p. m.	−5.6	1.3	NW 5	10−	10	Do.
17	3:44 a. m.	−9.3	1.5	NNW 3	9	11	Trace Ci, Ac. Light haze. Dense smoke haze N.
17	1:55 a. m.	−5.0	2.1	S 3	8+	11	2 Ci, Ac. Moderate haze. Dense smoke haze N.
21	3:47 a. m.	−7.9	1.4	N 5	7+	10	Trace Sc. Moderate haze. Dense smoke haze N.
21	1:46 a. m.	−6.1	1.6	N 4	7+	10	Trace Cu. Moderate haze. Dense smoke haze N.
21	0:08 p. m.	−4.8	1.8	NE 4	8+	10	Trace Cu. Light haze N. Moderate haze W.
21[1]	0:33 p. m.	−4.4	1.8	NE 4	8	10	Trace Cu. Light to moderate haze.
21[1]	1:43 p. m.	−3.9	1.5	NE 4	9	11	Trace Cu. Light haze to N
21	2:12 p. m.	−3.1	1.8	NE 4	9	11	Trace Cu. Light haze.
22	3:48 a. m.	−4.4	2.4	SSW 3	8+	10	Trace Ci. Light haze to N. Light ground fog below summit.
26	0:11 a. m.	−3.9	2.1	NW 2	8	8	Trace Ac, Cu. Light haze N, E, and W.
26	2:20 p. m.	−1.1	1.9	WNW 3	9−	10	Trace Cu. Smoke over Boston and harbor.
26	4:07 p. m.	−.3	1.5	W 3	9−	10	1 Ci, Cu.

[1] Indicates Smithsonian observation.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	h m		°	°	°				
Feb. 1	11 23	5760	−51.0	346.4	−11.0	121	.....	5	U. S. Naval.
		5758	−21.0	16.4	−6.5	54	.....	3	
		5756	−11.0	26.4	+12.5	485	.....	15	
		(1)	+26.0	63.4	+9.0	121	.....	7	
		5736	+82.0	119.4	+19.0	145	926	2	
Feb. 2	10 58	5764	−76.0	308.5	−16.0	24	.....	1	Do.
		5760	−39.5	345.0	−10.5	242	.....	4	
		5758	−8.5	16.0	−6.0	24	.....	2	
		5756	+2.0	26.5	+13.0	582	.....	16	
		(1)	+39.0	63.5	+9.0	97	969	5	
Feb. 3	16 2	5766	−80.0	288.6	−20.0	145	.....	2	Do.
		5764	−60.0	308.6	−17.0	48	.....	1	
		5760	−21.5	347.1	−10.5	291	.....	8	
		5756	+17.0	25.6	+13.0	630	.....	8	
		(1)	+60.0	68.6	+7.0	36	1,150	1	
Feb. 4	11 3	5766	−70.0	288.1	−21.0	158	.....	5	Do.
		5765	−60.0	298.1	−19.5	12	.....	1	
		5764	−49.0	309.1	−16.0	48	.....	2	
		5760	−10.5	347.6	−10.5	388	.....	18	
		5756	+28.0	26.1	+13.0	679	.....	22	
		(1)	+70.0	62	+7.0	24	1,309	1	
Feb. 5	12 5	5767	−63.0	281.4	−25.0	97	.....	6	Do.
		5766	−56.0	288.4	−20.5	97	.....	1	
		5765	−46.0	298.4	−19.5	12	.....	2	
		5764	−35.0	309.4	−17.0	48	.....	1	
		5760	+2.0	346.4	−10.5	291	.....	8	
		5756	+41.0	25.4	+13.0	436	981	15	
Feb. 6	11 16	5767	−48.0	283.7	−25.0	339	.....	29	Mt. Wilson.
		5766	−42.5	289.2	−20.0	121	.....	3	
		5765	−32.0	299.7	−18.5	12	.....	4	
		5764	−22.0	309.7	−17.0	48	.....	2	
		5763	−21.5	310.2	+22.5	48	.....	5	
		5760	+15.0	346.7	−11.0	339	.....	27	
		5768	+38.0	9.7	−18.0	48	.....	6	
		5756	+55.0	26.7	+13.5	436	1,391	24	
Feb. 7	11 4	5770	−79.0	239.6	+16.5	194	.....	2	Do.
		5767	−34.5	284.1	−25.0	824	.....	45	
		5766	−29.5	289.1	−20.5	121	.....	2	
		5765	−20.0	298.6	−19.0	48	.....	13	
		5764	−9.0	309.6	−17.0	48	.....	1	
		5763	−7.5	311.1	+21.5	24	.....	9	
		5760	+28.0	346.6	−11.0	485	.....	48	
		5768	+51.0	9.6	−18.0	36	.....	5	
		5756	+69.0	27.6	+13.5	291	.....	9	
		5769	+80.0	38.6	−15.0	12	2,083	1	
Feb. 8	11 1	5771	−76.0	229.5	+17.0	339	.....	8	U. S. Naval.
		5770	−62.5	243.0	+18.0	170	.....	2	
		5767	−21.0	284.5	−25.0	921	.....	28	
		5766	−16.5	289.0	−20.0	145	.....	3	
		5765	−7.0	298.5	−21.0	48	.....	7	
		5764	+3.0	308.5	−10.0	48	.....	2	
		5763	+6.0	311.5	+21.0	48	.....	3	
		5760	+43.0	348.5	−11.5	436	2,155	15	

[1] Not numbered.

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot or group	Area: Total for each day	Spot count	Observatory
1938	h m		°	°	°				
Feb. 9	11 3	5771	−64.0	228.3	+17.0	582		11	U. S. Naval.
		5770	−50.0	242.3	+17.0	170		2	
		5767	−6.0	286.3	−25.0	970		30	
		5766	−3.0	289.3	−20.5	145		1	
		5764	+17.5	309.8	−17.0	45		2	
		5760	+57.0	349.3	−10.0	242	2,157	9	
Feb. 10	10 55	5773	−76.0	203.2	−16.0	145		9	Do.
		5772	−57.0	222.2	−4.0	97		18	
		5771	−51.0	228.2	+17.0	679		45	
		5770	−36.5	242.7	+17.0	194		2	
		5767	+7.0	286.2	−24.5	1,212		55	
		5766	+10.0	289.2	−20.5	97		4	
		5764	+30.5	309.7	−17.0	36		3	
		5760	+71.0	350.2	−10.0	291	2,751	6	
Feb. 13	11 16	5777	−61.0	178.5	−14.0	436		20	Mt. Wilson.
		5776	−53.0	186.5	+10.0	36		4	
		5783	−53.0	186.5	+7.5	16		2	
		5774	−50.0	189.5	−9.0	533		38	
		5775	−49.0	190.5	−29.0	97		11	
		5782	−46.0	193.5	−21.0	73		3	
		5773	−37.0	202.5	−11.0	339		22	
		5781	−25.0	214.5	−7.0	73		11	
		5772	−14.0	225.5	−5.0	24		7	
		5771	−12.0	227.5	+15.0	970		96	
		5770	+3.0	242.5	+15.0	97		2	
		5767	+46.0	285.5	−27.0	1,406		72	
		5765	+60.0	299.5	−19.5	121		2	
		5778	+74.0	313.5	+18.0	48		1	
		5779	+76.0	315.5	−20.0	24	4,293	3	
Feb. 14	11 38	5777	−47.0	179.1	−14.0	388		20	U. S. Naval.
		5783	−39.5	186.6	+7.5	97		8	
		5774	−35.0	191.1	−9.0	436		20	
		5775	−33.0	193.1	−29.5	97		10	
		5782	−32.0	194.1	−21.0	73		5	
		5773	−23.0	203.1	−10.5	291		15	
		5781	−10.0	216.1	−7.0	73		5	
		5772	−2.0	224.1	−5.0	73		4	
		(1)	−1.0	225.1	+5.0	12		2	
		5771	+3.0	229.1	+16.0	630		25	
		5770	+18.0	244.1	+15.0	73		6	
		5767	+60.0	286.1	−26.0	1,261		30	
		5779	+88.0	314.1	−20.0	12	3,516	3	
Feb. 15	12 14	5777	−33.0	179.6	−13.0	339		16	Do.
		5783	−23.0	189.6	+7.5	218		10	
		5774	−22.0	190.6	−9.0	339		14	
		5782	−19.0	193.6	−20.5	73		3	
		5775	−19.0	193.6	−29.5	48		1	
		5773	−9.0	203.6	−10.0	267		10	
		5781	+2.0	214.6	−7.0	97		5	
		5772	+12.0	224.6	−5.0	97		6	
		5771	+15.0	227.6	+16.0	485		21	
		5770	+31.0	243.6	+13.0	61		2	
		5767	+75.0	287.6	−27.0	1,018	3,042	16	
Feb. 16	11 22	5785	−58.0	141.9	−8.0	73		5	Do.
		5777	−19.5	180.4	−12.5	388		22	
		5783	−10.5	189.4	+7.0	436		32	
		5774	−9.0	190.9	−9.0	339		20	
		5782	−8.5	191.4	−20.0	48		1	
		5775	−7.5	192.4	−30.0	61		3	
		5784	−2.5	197.4	+12.5	24		3	
		5773	+5.0	204.9	−10.0	242		12	
		5781	+13.5	213.4	−7.0	97		6	
		5772	+26.0	225.9	−5.0	97		13	
		5771	+29.0	228.9	+17.0	485		30	
		5770	+44.0	243.9	+14.0	61	2,351	4	
Feb. 17	11 38	5786	−86.0	100.6	−17.5	145		1	Mt. Wilson.
		5785	−45.0	141.6	−9.0	194		12	
		5777	−6.0	180.6	−12.5	436		24	
		5783	+4.0	190.6	+7.0	339		30	
		5774	+5.0	191.6	−9.0	388		26	
		5782	+6.0	192.6	−21.0	24		1	
		5775	+7.0	193.6	−30.0	36		6	
		5773	+19.0	205.6	−10.5	291		21	
		5781	+30.0	216.6	−7.0	48		3	
		5772	+40.0	226.6	−5.0	48		9	
		5771	+43.0	229.6	+17.0	679		42	
		5770	+58.0	244.6	+14.0	24	2,652	1	
Feb. 18	11 2	5786	−73.0	100.8	−17.5	194		3	U. S. Naval.
		5785	−33.0	140.8	−9.0	121		10	
		5777	+8.0	181.8	−12.5	436		20	
		5783	+17.0	190.8	+7.0	242		19	
		5775	+18.0	191.8	−30.0	24		2	
		5774	+19.0	192.8	−9.5	291		11	
		5773	+35.0	208.8	−10.5	145		5	
		5771	+55.0	228.8	+16.0	582		22	
		5772	+55.0	228.8	−6.0	36	2,071	1	
Feb. 19	13 49	5786	−59.0	100.1	−17.0	267		5	Mt. Wilson.
		5785	−17.0	142.1	−9.0	145		15	
		5777	+21.5	180.6	−13.0	388		21	
		5783	+31.0	190.1	+8.0	170		20	
		5774	+33.0	192.1	−9.5	291		13	
		5773	+50.0	209.1	−10.5	97		8	
		5787	+69.0	228.1	+29.0	61		5	
		5771	+70.0	229.1	+16.0	485		22	
		5772	+70.0	229.1	−7.0	24	1,928	1	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot or group	Area: Total for each day	Spot count	Observatory
1938	h m		°	°	°				
Feb. 20	11 32	5786	−46.0	101.2	−17.0	194		3	Mt. Wilson.
		5785	−8.0	139.2	−9.0	109		7	
		5777	+35.0	182.2	−13.0	170		4	
		5783	+45.0	192.2	+9.0	121		9	
		5774	+47.0	194.2	−10.0	97		3	
		5773	+63.0	210.2	−10.5	48	739	9	
Feb. 21	11 2	5791	−71.0	63.3	+7.0	194		5	Do.
		5786	−33.0	101.3	−17.0	388		30	
		5790	−27.0	107.3	−15.0	24		4	
		5789	−9.0	125.3	−25.0	12		3	
		5785	+8.0	142.3	−8.0	36		16	
		5788	+40.5	174.8	−28.0	16		4	
		5777	+49.0	183.3	−13.0	170		14	
		5783	+60.0	194.3	+8.0	97		12	
		5774	+61.0	195.3	−10.0	121		2	
		5773	+73.0	207.3	−10.5	97	1,155	15	
Feb. 22	10 41	5791	−57.5	63.8	+5.5	97		3	Do.
		5786	−20.0	101.3	−17.0	388		15	
		5790	−13.0	108.3	−15.0	36		4	
		5792	+13.0	134.3	−27.0	48		3	
		5789	+22.0	143.3	−25.0	24		1	
		5788	+57.0	178.3	−27.0	145		9	
		5777	+61.0	182.3	−13.0	121		5	
		5783	+74.0	195.3	+8.0	97		5	
		5774	+75.0	196.3	−9.0	121		2	
		5773	+80.0	201.3	−11.0	48	1,125	2	
Feb. 23	10 50	5794	−78.0	30.1	+13.0	97		1	Do.
		5791	−43.0	65.1	+5.0	97		4	
		5786	−7.0	101.1	−17.0	339		11	
		5790	−2.0	106.1	−15.0	97		9	
		5792	+33.0	141.1	−27.0	97		10	
		5793	+59.0	167.1	+7.0	48		3	
		5788	+70.0	178.1	−27.5	145		10	
		5777	+75.0	183.1	−13.0	48	908	2	
Feb. 24	12 8	5794	−62.5	31.7	+13.0	73		4	U. S. Naval.
		5791	−28.0	66.2	+6.0	61		12	
		5786	+7.5	101.7	−17.0	242		12	
		5790	+13.0	107.2	−15.0	73		13	
		5792	+47.0	141.2	−27.0	242		11	
		5793	+73.0	167.2	+7.5	218		6	
		5788	+84.0	178.2	−28.0	145	1,054	4	
Feb. 25	11 16	5794	−50.0	31.5	+12.5	73		3	Do.
		5791	−15.5	66.0	+6.0	73		11	
		5795	−13.0	68.5	+23.5	109		8	
		5786	+19.0	100.5	−18.0	170		4	
		5790	+27.0	108.5	−15.0	24		5	
		5796	+29.0	110.5	−8.0	61		7	
		5792	+60.0	141.5	−26.0	339	849	71	
Feb. 26	12 30	5794	−35.0	32.6	+12.5	61		1	Mt. Wilson.
		5791	+1.0	68.6	+6.0	48		3	
		5795	+2.0	69.6	+23.0	121		12	
		5786	+33.0	100.6	−18.5	170		8	
		5790	+41.0	108.6	−15.0	24		2	
		5796	+42.5	110.1	−8.0	121		13	
		5792	+74.0	141.6	−26.5	291	836	6	
Feb. 28	11 5	5797	+12.0	54.1	−12.5	242		9	U. S. Naval.
		5795	+27.0	69.1	+23.0	61		3	
		5786	+59.0	101.1	−17.5	97		3	
		5796	+69.0	111.1	−6.5	97	497	5	

[1] Not numbered.

Mean daily area for 25 days = 1,718.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR FEBRUARY 1938

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen, Sternwarte, Zurich, Switzerland]

February 1938	Relative numbers	February 1938	Relative numbers	February 1938	Relative numbers
1	*Mc* 62	11	*Ecd* 137	21	*Mc* 109
2	*b* 73	12	*d*	22	91
3	*d* 68	13		23	*Wac* 90
4	94	14	*Ebc* 200	24	*Mc* 92
5	*Eac* 85	15	171	25	*Ec* 83
6	128	16	*Eac*	26	*a* 81
7	*d* 124	17	*aad* 171	27	*Mac*
8	110	18	*a* 174	28	85
9	*b* 101	18	145		
10	*b*	20	98		

Mean: 23 days = 111.8.

a = Passage of an average sized group through the central meridian.
b = Passage of a large group or spot through the central meridian.
c = New formation of a group developing into a middle sized or large center of activity; E: on the eastern part of the sun's disc; W: on the western part; M: in the central circle zone.
d = Entrance of a large or average sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in Charge]

By L. P. HARRISON

Mean free-air data based on airplane weather and radiometeorograph observations during the month of February 1938 are given in table 1, which includes the basic elements, barometric pressure, temperature, and relative humidity at various standard geometric heights. "Means," which have been computed by the customary method of differences, are not given where there are less than 15 observations at the surface and less than 5 at the standard heights, except those within the layer of monthly vertical range of the tropopause for which 15 observations are also required. (For further details, see January 1938 Monthly Weather Review, Aerological Observations.)

Chart I shows that the mean *surface* temperatures during February were above normal almost over the entire country. A small area including Montana and part of North Dakota and a separate area in northern California had subnormal surface temperatures.

Table 1 shows that the mean free-air relative humidities in the vicinity of Nashville, Tenn., Spokane, Wash., and the California coast were relatively high on the whole in comparison to those which prevailed over adjacent land areas. They were relatively low at moderate and higher elevations (1.5–5 kilometers) in the vicinity of Pensacola, Fla.

Isobaric charts constructed by use of the mean monthly free-air barometric pressure over the country indicated the location of a statistical center of minimum pressure in the vicinity of Sault Ste. Marie, Mich., and a center of maximum pressure toward the Gulf of Mexico.

Table 2 shows the free-air resultant winds based on pilot-balloon observations made near 5 a. m. (seventy-fifth meridian time) during February. The resultant wind directions were generally close to normal over the greater portion of the country, with notable departures near the west coast, the central and southern Plateau regions and the Florida Peninsula. At Oakland and San Diego, Calif., through the stratum from 0.5 to about 2.5 or 3.0 kilometers, mean sea level, the resultant winds were mostly oriented counterclockwise from normal by amounts ranging from about 140° to 70° over the former station and 100° to 40° over the latter. Similarly, at Seattle, Wash., the amounts of counterclockwise orientation were from about 20° to 135°, and at Spokane, Wash., between 1–3 kilometers, mean sea level, they were about 40° to 65°. However at 4 kilometers, over the latter place, the orientation was 55° clockwise. At 2.5 kilometers, mean sea level, over Medford, Oreg., the orientation was counterclockwise about 50°. Thus along the west coast, the northerly components normal during February were this month replaced by southerly components in the lower levels, and westerly components were more pronounced than usual.

The resultant directions at Salt Lake City, Utah, and Albuquerque, N. Mex., in the layer 2 to 4 kilometers, mean sea level, were oriented counterclockwise from normal by amounts ranging from 20° to 60°, and 20° to 45°, respectively. Here too the southerly components were more pronounced than generally is the case. At Key West, Fla., the monthly resultant directions were rotated counterclockwise from the normal by amounts which increased from 26° at 0.5 kilometer to 248° at 3 kilometers, mean sea level, so that easterly and northerly components were dominant instead of the more usual southerly and westerly components at moderate elevations; i. e., the air resultant flow was from the Atlantic Ocean rather than from the Gulf of Mexico and the Caribbean Sea as has been the general rule in recent years in this region.

The monthly resultant velocities of the free-air winds up to the levels for which data were available were generally in excess of the normal westward of a line running from Vancouver to, say, New Orleans, La., and deficient with respect to the normal eastward of that line, except over the Mississippi and Ohio River valley basin up to 1.5 kilometers, mean sea level, where excesses also prevailed. Most of the departures of resultant velocity from normal fell within the range ±2 meters per second, but in several areas significantly larger departures occurred. In particular, the departures from normal in meters per second at various elevations above sea level were: at 1 kilometer, Oklahoma City, Okla., +3.7, Chicago, Ill., +3.2, Detroit, Mich., −3.8; at 1.5 kilometers, Medford, Oreg., +3.8, Seattle, Wash., +3.2; at 2.0 kilometers, Atlanta, Ga., −3.7; at 2.5 kilometers, Spokane, −4.8, Atlanta, −4.0; at 3.0 kilometers, Spokane, −3.6, Medford, −3.1, Cheyenne, Wyo., −4.0, Pensacola, Fla., −4.6, Boston, Mass. −3.5; at 4 kilometers, Oakland, Calif., +8.1, San Diego, Calif., +4.4, Albuquerque, N. Mex., +4.2, Spokane, −3.6, Pensacola, −3.4; at 5 kilometers, San Diego, +4.8, Albuquerque, +9.4, Atlanta, −5.8.

Table 3 shows the maximum free-air wind velocities and their directions for various sections of the United States during February as determined by pilot balloon observations. The extreme maximum was 61.6 meters per second from the north at 8,600 meters, mean sea level, over Modena, Utah, on February 17.

TABLE 1.—*Mean free-air, barometric pressures (P) in mb., temperatures (T) in ° C., and relative humidities (R. H.) in percent, obtained by airplanes or radiometeorographs during February 1938*

Stations	Altitude (meters) mean sea level																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of obs.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.
Barksdale Field,[1] La. (52 m)	27	1,017	10.4	82	963	10.9	71	907	9.6	63	854	8.6	57	804	6.6	55	755	4.5	54	710	2.9	43	627	−2.9	39			
Billings, Mont.[2] (1,090 m)	25	891	−6.4	75							846	−1.8	60	794	−1.6	55	745	−4.6	55	699	−8.1	57	614	−14.9	58	537	−22.0	56
*Boston, Mass. (5 m)	25	1,020	−1.4	77	959	−3.1	78	901	−4.1	76	843	−4.8	74	793	−6.3	72	742	−8.1	70	696	−10.1	68	610	−14.7	65	534	20.5	65
*Burbank, Calif. (220 m)	26	992	6.8	80	958	9.7	68	902	7.1	68	847	3.8	67	798	0.7	65	748	−1.7	60	704	−3.6	56	618	−8.8	55	543	−14.8	53
Cheyenne, Wyo.[2] (1,873 m)	25	810	−3.8	66										797	−1.4	60	748	−2.5	52	702	−5.8	51	618	12.5	52	540	−18.7	49
Coco Solo, C. Z.[3] (15 m)	26	1,010	25.5	82	956	21.9	93	903	18.8	91	851	15.7	86	802	13.8	64	756	12.5	46	712	10.2	40	630	5.1	29	558	0.1	13
El Paso, Tex.[2] (1,194 m)	27	884	7.1	57							851	10.3	45	802	7.7	43	753	4.7	45	708	1.2	47	624	−5.4	47	549	−12.0	43
Fargo, N. Dak.[2] (274 m)	28	990	−14.1	84	961	−11.9	83	900	−8.1	76	844	−6.6	69	792	−5.8	62	742	−7.1	56	696	−9.2	54	610	−14.7	57	534	−20.5	56
Kelly Field, Tex.[1] (206 m)	21	998	12.7	77	964	13.0	70	908	11.1	66	855	9.3	64	805	8.8	50	757	6.6	46	712	4.4	41	628	−1.5	39	554	−7.8	34
Lakehurst, N. J.[3] (39 m)	20	1,020	−0.7	72	963	−0.6	62	904	−0.9	57	849	−2.1	53	797	−4.1	49	747	−5.8	44	701	−8.4	41	615	−14.6	39	539	−21.2	41
Maxwell Field, Ala.[1] (52 m)	26	1,018	10.6	78	965	11.2	66	908	9.1	66	855	7.0	64	804	5.3	56	756	3.7	46	711	1.4	39	626	−3.9	31	552	−10.1	31
Mitchel Field, N. Y.[1] (29 m)																												
Nashville, Tenn.[2] (180 m)	28	1,001	7.8	78	963	7.4	77	906	6.0	75	852	5.2	71	801	2.9	68	753	1.1	56	707	−1.3	53	623	−6.7	44	547	−13.2	44
Norfolk, Va.[3] (10 m)	15	1,026	4.6	78	966	4.5	64	908	2.6	58	853	1.7	52	802	0.3	47	752	−1.0	42	707	−2.7	38	622	−7.1	35	546	−12.2	33
Oakland, Calif.[3] (2 m)	28	1,017	9.0	86	957	8.6	74	901	5.8	73	847	3.0	69	796	0.0	67	747	−2.6	60	702	−5.1	59	616	−11.0	60	541	−17.7	53
Oklahoma City, Okla.[1] (391 m)	25	975	4.7	78	962	6.1	72	905	7.1	64	851	6.4	59	801	5.6	48	753	2.9	44	707	0.0	43	623	−6.5	42	548	−13.0	39
Omaha, Nebr.[2] (300 m)	28	985	−4.1	85	961	−2.6	83	902	0.3	67	848	1.0	56	796	−0.2	51	747	−2.0	44	702	−5.0	43	617	−11.6	44	541	−19.5	48
Pearl Harbor, T. H.[3] (6 m)	28	1,014	20.6	89	958	20.5	80	903	18.3	74	852	15.9	73	803	13.7	65	756	12.1	51	712	9.9	42	630	5.5	33	557	−0.2	30
Pensacola, Fla.[3] (13 m)	23	1,023	11.5	82	965	11.9	63	909	10.7	56	855	8.6	51	805	6.9	38	757	5.9	24	712	3.4	22	628	−1.9	18	554	−7.7	16
St. Thomas, V. I.[3] (8 m)	27	1,018	23.5	72	963	19.3	83	907	15.3	89	854	12.1	86	805	9.9	79	757	9.2	56	713	7.4	44	631	2.4	34	557	−3.2	31
Salt Lake City, Utah[1] (1,288 m)	28	872	0.4	76							850	1.9	65	798	−0.7	62	748	−4.1	65	703	−7.4	65	616	−13.9	66	540	−20.3	60
San Diego, Calif.[3] (10 m)	25	1,018	9.4	85	960	11.0	72	904	7.9	68	850	4.6	66	799	1.5	63	750	−0.5	55	705	−2.7	52	620	−7.8	47	546	−14.3	43
Sault Ste. Marie, Mich.[2] (221 m)	24	997	−9.8	80	961	−11.0	83	901	−10.6	77	844	−10.6	68	790	−11.0	60	740	−11.9	56	693	−13.9	55	606	−18.5	53	529	−24.3	52
Scott Field, Ill.[1] (135 m)	16	1,005	4.5	84	961	5.3	76	904	5.6	61	850	4.3	58	799	2.6	49	750	0.4	42	705	−2.3	40	620	−8.0	38	546	−14.6	40
Seattle, Wash.[3] (10 m)	16	1,009	4.2	80	951	4.5	67	893	2.0	64	839	−1.1	63	788	−3.7	57	740	−6.6	52	696	−9.8	47	613	−17.1	46			
Selfridge Field, Mich.[1] (177 m)	24	1,001	−2.9	84	961	−4.5	85	902	−5.4	81	846	−4.2	61	794	−5.4	62	744	−6.8	56	698	−8.8	51	612	−13.8	46	536	−20.3	43
Spokane, Wash.[3] (597 m)	28	944	−1.1	90				898	−0.9	87	843	−2.2	82	792	−4.9	78	742	−7.8	77	696	−10.7	72	609	−17.9	70	532	−25.3	68
Washington, D. C.[3] (13 m)	21	1,025	1.9	76	965	1.6	66	907	−0.1	63	852	−0.6	60	800	−1.1	56	751	−2.5	47	705	−4.8	44	619	−11.0	49	543	−17.0	47
Wright Field, Ohio[1] (244 m)																												
Chicago, Ill.[2] (187 m)	28	999	0.8	83	962	−0.3	86	903	−0.6	79	848	−0.2	67	796	−1.2	60	747	−3.3	57	701	−5.7	57	616	−10.6	52	540	−16.7	47

Stations	Altitude (meters) mean sea level)																											
	6,000			7,000			8,000			9,000			10,000			11,000			12,000			13,000			14,000		
	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.
Boston, Mass.	465	−27.0	62	403	−33.9	57	350	−41.1	56																		
Burbank, Calif.	475	−21.2	52	418	−27.5	52	359	−34.2	52	312	−40.5	52	268	−48.9													

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Stations	Altitude (meters) mean sea level																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of obs.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.
St. Thomas, V. I.[3] (8 m)	30	1,018	24.3	76	962	20.5	87	907	16.7	92	854	13.6	91	805	11.1	83	758	11.5	47	713	10.1	27	632	4.4	18	539	−1.8	13

*Observations by radiometeorograph. Stations not so marked have observations by airplane. [1] Army. [2] Weather Bureau. [3] Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations, except those levels comprised within the layer in which the tropopause occurred, where at least 15 are also required as a basis.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during February 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (156 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (283 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Nashville, Tenn. (184 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	348	0.9	346	1.2	259	1.3	304	2.4	271	3.0	232	0.3	289	0.6	339	1.0	10	1.5	12	1.1	46	2.6	351	0.2	211	1.3
500			19	0.7			290	7.4			255	2.9	237	3.4	238	1.9	339	0.4	234	0.8	81	6.6	81	0.5	216	4.9
1,000			273	1.5			315	7.6			259	11.0	243	10.0	236	4.5	257	3.7	247	3.0	99	5.4	148	4.2	240	7.9
1,500			283	4.7	235	5.4	319	8.2			279	10.5	251	9.4	265	8.0	269	3.8	259	4.2	96	4.5	171	7.0	268	7.8
2,000	243	2.5	276	5.4	262	5.3	309	11.2	272	4.6	300	10.3					285	7.0	297	6.9	79	3.1	197	7.0	272	6.7
2,500	247	5.6	279	5.9	275	5.7	306	13.9	266	6.5							297	10.3	296	7.1	36	1.9	206	5.5		
3,000	246	9.2	284	5.9	281	7.2	302	10.7	275	8.1							290	9.5	301	11.1	13	1.6	290	1.1		
4,000	248	15.5	284	9.8	271	8.9			269	8.6									296	13.1						
5,000	248	21.2	282	11.4																						

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during February 1938*—Continued

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii[1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	327	2.5	141	2.7	262	0.3	350	1.8	10	1.0	27	2.9	237	1.6	151	4.0	75	0.7	76	1.7	133	1.0	104	1.1	305	1.6
500	308	6.0	202	2.8	200	2.4	333	1.8	158	1.1	63	2.4	237	4.4			225	0.4	93	2.1	154	3.5			289	5.4
1,000	306	8.8	229	4.8	232	8.4	287	5.1	199	1.3	298	2.6	259	7.6			251	0.7	317	3.1	180	5.2	134	2.3	300	7.3
1,500	302	10.9	243	4.9	250	7.7	291	6.2	219	2.2	319	4.1	279	9.7	161	5.0	197	1.3	312	6.1	184	7.0	204	3.4	292	10.2
2,000	311	12.9	252	4.9	265	8.9	295	7.4	233	3.3	303	5.1	272	10.1	181	5.2	228	3.2	321	7.5	174	4.9	219	4.1	291	10.9
2,500	299	10.2	256	4.3	265	9.3	290	9.1	266	3.6	296	5.2	300	11.2	199	4.8	253	4.1	318	8.6	165	5.4	231	2.6	289	12.5
3,000			307	5.9	267	8.2	281	9.8	276	5.6	304	3.0	285	11.5	215	5.5	256	7.1	320	12.1	154	4.7	219	2.6	292	13.2
4,000			324	12.9	277	10.7	255	8.6	257	4.0	302	5.3			224	6.4	285	10.9					346	2.0		
5,000																	286	10.3								

[1] Navy stations.

TABLE 3.—*Maximum free-air wind velocities (meters per second), for different sections of the United States based on pilot balloon observations during February 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	42.1	NNW	2,500	28	Kylertown	52.1	NNW	2,950	28	Kylertown	33.2	NW	5,850	7	Columbus.
East Central [2]	40.8	NW	1,900	28	Washington	42.8	NW	3,060	28	Greensboro	36.4	WNW	8,130	7	Knoxville.
Southeast [3]	36.0	WNW	1,560	27	Charleston	35.6	WNW	4,530	28	Charleston	37.6	NW	10,000	1	Key West.
North Central [4]	40.2	NNW	2,330	26	Minneapolis	42.8	NW	3,610	26	Fargo	38.0	WNW	5,590	9	Fargo.
Central [5]	42.2	WSW	1,890	6	Moline	39.0	NW	2,930	27	Evansville	36.8	WSW	5,560	13	Wichita.
South Central [6]	33.2	SSW	1,390	1	Oklahoma City	37.0	WSW	3,370	5	Oklahoma City	36.4	WNW	6,970	25	Amarillo.
Northwest [7]	46.2	SSW	2,300	5	Medford	40.2	WSW	5,000	7	Boise	46.0	NNW	7,130	15	Portland.
West Central [8]	37.0	SE	810	9	Sacramento	38.0	SSW	2,800	10	Sacramento	61.6	N	8,600	17	Modena.
Southwest [9]	31.5	SW	1,180	6	Havre	39.0	WSW	5,000	4	Albuquerque	59.0	NNW	10,540	17	Las Vegas.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in Charge]

By BENNETT SWENSON

Precipitation during February was heavy over most of a wide belt extending from Texas and New Mexico northeastward over the Lake region, and also in nearly all of the Pacific slope area. The relatively heaviest amounts occurred in California and the lower Great Plains where the rainfall was from 200 to 400 percent or more of the normal. On the other hand, in the South Atlantic slope and East Gulf of Mexico drainage area, it was one of the driest months of February of record.

The principal floods during February occurred in the rivers in Michigan, southern Wisconsin, and Illinois, the Meramec River in Missouri, the Wabash-White Rivers in Indiana, the White Basin in Missouri and Arkansas, the Arkansas and Red Basins, the St. Francis River in Missouri and Arkansas, the Trinity River in Texas, and in the San Joaquin and Sacramento Rivers in California.

St. Lawrence drainage.—Heavy rains in Michigan on February 5 and again on the 12th–13th caused two sharp rises in the Grand and Saginaw River systems and other small streams in southern Michigan. The snow cover was not excessive and did not have an appreciable effect on the flood, but the mild temperature and rain caused the solid ice in the rivers to break up and resulted in ice jams that caused increased overflow.

The storm of February 12–13 broke all records for maximum short period rainfall, as well as for the 24-hour period for February at several points. The greatest amount occurred at East Lansing, Mich., where 4.33 inches occurred within 24 hours. This is the greatest of record at that point for the month of February or any winter month, and for any month in the past 33 years.

The intensity of the rainfall and presence of ice in the streams produced sudden rises that gave little time for warnings except in the lower portions of the streams. Damages have been estimated as follows: Grand River, $95,200; Saginaw River, $22,800; other rivers in southeastern Michigan, $119,350.

Atlantic slope drainage.—A severe local flood occurred in the Mohawk River at Amsterdam, N. Y., on February 7–8. The river rose 10.3 feet in 24 hours on February 6–7, due to moderate rains and high temperatures which caused moderately heavy run-off in the tributaries of the Mohawk River. In the meantime, the ice that had moved out of the Schoharie River on January 25 and had moved slowly

down the Mohawk, had jammed below the city of Amsterdam and the backing up of the water above the ice jam resulted in one of the worst floods ever experienced in that city. The estimated damage reached approximately $100,000.

Colder weather on the 8th ameliorated conditions considerably, and although flood stage was exceeded at Schenectady, N. Y., by 1.4 feet, no damage resulted at that point.

East Gulf of Mexico drainage.—Heavy rains on the 18th–19th resulted in sharp rises in the Pearl and Pascagoula Rivers. However, fairly low stages prevailed before the rains occurred and no damage of consequence resulted.

Upper Mississippi Basin.—The following report on the floods in the Rock River Valley during January and February is made by the official in charge at Davenport, Iowa:

A flood of major proportions occurred on the Rock River during January and February. Overflows occurred on the minor tributaries, the Galena in Illinois, and Wapsipinicon in Iowa during this time.

Precipitation over northern Illinois on January 23 and 24, principally over the Rock River Valley, averaged 2.25 inches, with individual amounts of almost 3 inches. This precipitation falling on frozen ground and augmented by frozen ice and snow caused destructive floods on the Rock River and its tributaries. Ice gorges were formed which added to the destruction. These conditions began in the latter part of January and continued until February 25 in the lower part of the valley. The only gage maintained by the Weather Bureau on the Rock River is at Moline Bridge, Ill., and at that point the river exceeded flood stage on January 25 and continued above flood stage until February 26, with a secondary rise occurring on February 8, 9, and 10.

In the first rise a stage of 13.8 feet was reached at Moline Bridge on January 30. Additional rains and thawing began on February 6 and 7 and resulted in a second crest of 13.6 feet on February 10.

Two lives were lost during the flood and the property damage is estimated at about $565,000.

The Illinois was at or slightly above flood stage at some points, beginning in January and continuing into March in the lower portion. So far the flood has been of little consequence.

The Meramec River was in flood from February 18 to 22. The river rose to 18.7 feet at Sullivan, Mo., on February 19, or 7.7 feet above flood stage, and to 24.0 feet at Valley Park, Mo., on February 21, or 10 feet above flood stage. However, no material damage was reported, owing to the earliness of the season.

Ohio Basin.—Some flooding occurred in portions of the Wabash-White Basin, beginning on February 19, and continuing into March in some parts of the West Fork and White Rivers. Practically no crops had been seeded and consequently little damage resulted.

Lower Mississippi Basin.—Excessively heavy rains over Arkansas, eastern Oklahoma, and northeastern Texas from about February 14 to 19, resulted in general floods in the White, Arkansas, Red, and St. Francis Basins, in most cases, exceeding the stages reached in the floods late in January and early in February. Total rainfall from the 14th to the 19th of February was 8.84 inches at Fort Smith, Ark., and 10.51 inches at Webbers Falls, Okla.

The White River reached a crest stage of 42.0 feet at Calico Rock, Ark., on February 18–19, or 24 feet above flood stage, and 31.5 feet at Georgetown, Ark., on February 23, 10.5 feet above flood stage, and exceeding the highest gage reading of record at that place, 31.3 feet on March 18, 1935. The total losses in the basin are estimated at slightly more than $130,000.

The Arkansas River exceeded flood stage in the lower portion from about Webbers Falls, Okla., to the mouth, from February 16 to 25. Of the tributaries of the Arkansas River, the small streams in eastern Oklahoma and extreme western Arkansas were probably the most seriously affected. The Poteau and Petit Jean Rivers reached reported stages of about 10 to 15 feet above flood stage. Although no river gaging stations on the North or South Canadian Rivers reported flood stages, considerable damage occurred at some points. Total losses in the Arkansas Basin are estimated at about $350,000.

The St. Francis River was in flood most of the month, and continued at the end of the month at some points. Two levee breaks occurred near Bertig, Ark., on the Arkansas side, on February 26, but the property loss is believed to have been slight.

The floods in the Red and Ouachita Rivers, which began late in January, had barely subsided when the heavy rains of February 14 to 19 caused a second flood which exceeded the first at most points. Losses resulting from high water were considerable, and levee breaks caused flooding of large areas. Estimated losses in the second flood in the Red River above Shreveport, La., are approximately $550,000. The flood was still in progress at the end of February and estimates on the losses below Shreveport are not available at this time.

The Ouachita River reached a stage of 41.1 feet at Camden, Ark., on February 22, or 15.1 feet above flood stage, and 0.4 foot higher than the crest of January 27. Revised estimates of losses in the Ouachita Basin during the last week of January indicate a total of $75,000. Figures for the February flood have not been received.

West Gulf drainage.—A moderately heavy flood occurred during February in the Trinity River in Texas, following the January flood. This flood began about February 17, and like the January flood, was most severe in the upper portion. At most points the second flood exceeded the first and resulted in estimated losses of about $60,000 in the upper portion of the Trinity River basin.

Pacific slope drainage.—Following the record December flood in the upper Sacramento Basin, there was a period of more than a month of deficient precipitation, during which time the streams receded slowly to normal winter levels. However, near the end of January a period of heavy rain began which continued throughout the first two weeks of February, over most of the Sacramento and San Joaquin Basins and resulted in a second major flood of the season.

The main flood damage was confined to the Sacramento-San Joaquin delta region, with an estimated total loss for the entire basin of approximately $1,680,000.

Table of flood stages during February 1938
[All dates in February unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
ST. LAWRENCE DRAINAGE					
Lake Michigan					
Red Cedar:	*Feet*			*Feet*	
Williamston, Mich.	6	13	16	9.3	13
		19	19	6.4	19
East Lansing, Mich.	8	13	16	10.5	14
Grand:					
Lansing, Mich.	11	14	14	11.6	14
Ionia, Mich.	21	14	15	21.5	14
Lowell, Mich.	15	15	16	15.9	15
Cass: Vassar, Mich.	13	6	9	16.8	7
Lake Huron					
Flint:					
Columbiaville, Mich.	8	6	22	10.5	8
Flint, Mich.	11	13	14	11.2	13
Shiawassee: Owosso, Mich.	6	13	19	7.1	14
Pine: Alma, Mich.	6	5	11	10.6	6
		12	17	8.3	13
Chippewa: Mount Pleasant, Mich.	12	6	9	13.2	6
		14	14	12.6	14
Tittabawassee: Midland, Mich.	18	7	8	19.5	7
		14	14	19.1	14
Lake Erie					
St. Marys: Decatur, Ind.	13	19	22	14.2	20
ATLANTIC SLOPE DRAINAGE					
Connecticut: Bethel, Vt.	8	7	7	8.0	7
Mohawk: Schenectady, N. Y.	15	9	9	16.4	9
Tioughnioga: Whitney Point, N. Y.	12	7	8	13.6	7
Chenango: Sherburne, N. Y.	8	6	8	9.0	7
Susquehanna: Oneonta, N. Y.	12	7	10	13.2	7
EAST GULF OF MEXICO DRAINAGE					
Pearl:					
Jackson, Miss.	18	22	(1)	20.8	26
Pearl River, La.	12	25	(1)	13.5	28
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Rock: Moline, Ill.	10	Jan. 25	26	13.8	Jan. 30
				13.6	10
Skunk: Augusta, Iowa	15	8	9	18.0	9
Illinois:					
Peru, Ill.	17	7	7	17.1	7
Havana, Ill.	14	Jan. 30	(1)	15.0	1
Beardstown, Ill.	14	28	(1)	14.0	28–Mar. 2
Bourbeuse: Union, Mo.	12	19	21	14.0	20
Meramec:					
Sullivan, Mo.	11	18	20	18.7	19
Pacific, Mo.	11	18	22	19.3	21
Valley Park, Mo.	14	18	22	24.0	21
Missouri Basin					
Gasconade: Jerome, Mo.	15	18	21	17.3	19
Ohio Basin					
Allegheny: Lock No. 8, Mosgrove, Pa.	24	7	7	25.5	7
Scioto: La Rue, Ohio	11	19	20	11.9	20
West Fork of White:					
Anderson, Ind.	8	11	(1)	10.2	20
Elliston, Ind.	18	20	25	22.1	22
Edwardsport, Ind.	12	19	(1)	18.0	24
White:					
Petersburg, Ind.	16	22	(1)	18.7	26, 27
Hazleton, Ind.	16	22	(1)	19.1	27, 28
Wabash:					
Lafayette, Ind.	11	19	23	15.9	21
Covington, Ind.	16	20	24	19.1	22
Terre Haute, Ind.	14	20	27	15.7	25
White Basin					
Current: Doniphan, Mo.	10	18	21	18.0	19
Black:					
Leeper, Mo.	11	18	19	16.0	18
Poplar Bluff, Mo.	14	18	22	17.4	20
Black Rock, Ark.	14	16	Mar. 10	25.1	19
White:					
Cotter, Ark.	21	17	21	31.0	19
Calico Rock, Ark.	18	16	22	42.0	18–19
Batesville, Ark.	23	16	23	39.5	19

Table of flood stages during February 1938—Continued
[All dates in February unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
MISSISSIPPI SYSTEM—continued					
White Basin—Continued					
White—Continued.					
Newport, Ark.	26	18	27	33.4	20
Georgetown, Ark.	21	Jan. 30	7	22.3	2
		18	Mar. 12	31.5	23
Clarendon, Ark.	26	Jan. 29	13	27.7	7
		19	Mar. 23	35.0	28
St. Charles, Ark.	24	Jan. 29	(1)	31.8	Mar. 5
Arkansas Basin					
Poteau: Poteau, Okla.	21	16	23	36.0	19
Petit Jean: Danville, Ark.	20	Jan. 31	2	21.5	1
		17	23	29.3	18
Arkansas:					
Webbers Falls, Okla.	23	17	20	26.8	18
Fort Smith, Ark.	22	16	22	33.2	19
Van Buren, Ark.	22	16	23	32.4	19–20
Ozark, Ark.	22	17	22	28.9	20
Dardanelle, Ark.	22	17	23	29.6	19
Morrilton, Ark.	20	18	24	27.8	21
Little Rock, Ark.	23	19	24	26.2	22
Pine Bluff, Ark.	25	19	25	31.7	23
Red Basin					
Little Missouri: Boughton, Ark.	20	18	20	23.6	19
Ouachita:					
Arkadelphia, Ark.	17	18	21	29.0	19
Camden, Ark.	26	20	Mar. 1	41.1	22
Little: Whitecliffs, Ark.	25	Jan. 24	1	31.0	Jan. 26
		19	28	30.7	20
Sulphur:					
Ringo Crossing, Tex.	20	18	24	30.5	19
Naples, Tex.	22	Jan. 23	4	35.0	Jan. 25
		20	(1)	30.4	21–22
Cypress: Jefferson, Tex.	18	Jan. 26	1	25.7	Jan. 27
Red:					
Arthur City, Tex.	27	18	22	34.7	19
Index, Ark.	25	19	27	34.4	23
Fulton, Ark.	25	Jan. 24	2	32.9	Jan. 28
		19	(1)	36.4	24
Springbank, Ark.	37	27	(1)	38.1	27
Grand Ecore, La.	33	Jan. 31	8	35.7	4
		24	(1)	------	------
Alexandria, La.	32	Jan. 30	13	36.9	7
		22	(1)	------	------
Lower Mississippi Basin					
Big Lake Outlet: Manila, Ark.	10	Jan. 26	(1)	17.5	24–25
St. Francis:					
Fisk, Mo.	20	18	25	24.9	21
St. Francis, Ark.	18	Jan. 29	9	19.9	1
		18	(1)	23.4	24
Tallahatchie: Swan Lake, Miss.	26	Jan. 28	(1)	30.3	6
WEST GULF OF MEXICO DRAINAGE					
Sabine: Logansport, La.	25	4	16	31.3	7
Elm Fork: Carrollton, Tex.	6	17	21	12.6	18
Trinity:					
Dallas, Tex.	28	17	24	41.3	19
Trinidad, Tex.	28	Jan. 23	5	39.8	Jan. 29
		19	(1)	44.8	24
Long Lake, Tex.	40	Jan. 27	8	45.0	Jan. 29
		24	(1)	45.3	27
Liberty, Tex.	24	3	17	26.1	12
Brazos: Waco, Tex.	27	18	18	28.1	18
PACIFIC SLOPE DRAINAGE					
San Joaquin Basin					
Mokelumne: Bensons Ferry, Calif.	12	12	15	15.4	12
San Joaquin: Lathrop, Calif.	17	14	19	18.7	15
Sacramento Basin					
Sacramento:					
Red Bluff, Calif.	23	8	10	24.8	8
		14	14	23.1	14
Knights Landing, Calif.	30	9	18	32.0	12
Columbia Basin					
Coast Fork: Saginaw, Oreg.	9	6	7	10.6	6
Willamette: Harrisburg, Oreg.	10	7	8	10.6	7

[1] Continued at end of month.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, FEBRUARY 1938

By H. C. HUNTER

Atmospheric pressure.—Several unusual features were noted in the distribution of pressure during February 1938. Substantially all the North Atlantic area north of the thirtieth parallel had average pressure greater than normal. There was one marked exception; around the Azores, near the normal position of the center of the North Atlantic HIGH, pressure averaged about one-eighth of an inch lower than normal. This was entirely the result of persistent low pressure during the period from the 13th to the 25th. On the 21st 28.86 inches was recorded at Horta, an exceptionally low barometer reading for that station; 2 days later the Italian motorship *Vulcania* reported 28.38 inches about 400 miles west of Horta.

Near the British Isles and northwestward to Iceland pressure averaged much greater than normal, owing chiefly to high barometer most of the time from the 10th to 23d, inclusive. The maximum readings here were about 30.8 inches.

There was a comparatively brief period of even greater pressure in the region of Nova Scotia and the Gulf of St. Lawrence where, on the 2d and 3d, several shore stations reported the pressure as almost 31 inches.

The various stations along the North American coast reported pressure for the month averaging usually from one-tenth to three-tenths inch above normal, the greatest departure being found at the northern tip of Newfoundland. For the most part the highest readings in this section of the Atlantic occurred early in the month, and the lowest near the end.

The extremes of pressure found in vessel reports at hand are 30.90 and 28.11 inches. The former reading was noted near the southeastern coast of Newfoundland during the forenoon of the 3d by the American steamship *Cliffwood*. However, at the land station at Halifax, Nova Scotia, there was on that day a reading higher by 0.08 inch, as table 1 shows. The low reading was reported by radio from an unidentified vessel, not far to westward of the Orkney Islands, on the forenoon of the 1st.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, February 1938*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.58	+0.05	30.28	17	28.98	2
Reykjavik, Iceland	29.78	+.24	30.80	19	28.62	25
Lerwick, Shetland Islands	30.05	+.33	30.80	18	28.29	1
Valencia, Ireland	30.25	+.35	30.74	11	29.50	26
Lisbon, Portugal	30.26	+.16	30.56	28	29.92	22
Maderia	30.07	.00	30.41	1	29.50	19
Horta, Azores	30.02	−.13	30.64	1	28.86	21
Belle Isle, Newfoundland	30.00	+.29	30.64	3	29.02	11
Halifax, Nova Scotia	30.10	+.19	30.98	3	29.12	28
Nantucket	30.14	+.10	30.83	2	29.19	28
Hatteras	30.22	+.11	30.64	8	29.52	27
Bermuda	30.16	+.04	30.44	9, 13	29.54	26
Turks Island	30.08	.00	30.19	9	29.98	25
Key West	30.14	+.07	30.33	9	29.91	24
New Orleans	30.21	+.12	30.46	1	29.86	18

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—There was less storminess over the North Atlantic than during January 1938, and somewhat less than the average storminess of February. However, the month included more storms of marked strength than had occurred during December 1937.

As previously stated, the lowest pressure reading of the month was noted on the first day, west of the Orkney Islands. A LOW of great extent and intensity was then centered between the north coast of Scotland and the Faroe Islands; shortly thereafter it moved to northeastward, losing energy, and by noon of the 3d the center was between North Cape and Spitzbergen.

A LOW near the Gulf of St. Lawrence on the 4th affected shipping to southward and eastward of Newfoundland on that and the 2 following days as it traveled northeastward to near western Iceland.

Mainly to the southward of the path of this storm, lay the route of another which crossed the Lake region on the 6th and was central near Newfoundland from the evening of the 7th to the morning of the 9th, after which it turned to northward and conditions improved over the Grand Banks. Chart IX shows the situation on the 7th.

From the 5th to the 9th pressure was quite high near Bermuda and, in connection with this HIGH and the normal pressure of the tropical regions to southward, many vessels near the Greater Antilles or to eastward of them encountered trade winds of more than average force.

On the 10th a LOW moving eastward from the continent gained great strength over and near Nova Scotia and to southward of Newfoundland, and important gales resulted on that day and the 11th eastward to about the thirty-fifth meridian along the chief steamship lanes. After the 11th the storm turned to the northward and practically all Atlantic areas experienced comparatively quiet weather until the 17th. On this day a storm of rather small area, to southeastward of Newfoundland, deepened considerably near the center, causing winds of marked force within a limited area. The American steamship *Azalea City*, bound from Pensacola to Liverpool, lost its propeller during the afternoon of the 17th, and after drifting for a considerable time was taken in tow back to Boston. Chart X presents the conditions on the 17th.

The LOW near Newfoundland on the 17th took a southeastward course on the ensuing days, to reach the vicinity of the Azores by the 21st. Another LOW, central early on the 20th just to eastward of Delaware Bay, moved rapidly toward the Azores and merged on the 22d with the preceding LOW. Unusually strong winds were met by many vessels at this time near and for some distance to eastward of mid-ocean, mostly between the thirty-fourth and fortieth parallels of latitude, but in a few cases close to or south of the thirtieth. The only instance of a wind of force 12 reported this month from Atlantic waters occurred on the 22d in the northwestern quadrant of this storm area, the vessel being the American liner *President Van Buren*, bound from the Mediterranean to New York.

By the 24th it was evident that this LOW was moving rapidly to the northward, and on the next day it united with another LOW to the westward of Iceland. Stormy conditions prevailed in the middle portion of the steamship lanes to northwestern Europe while this northward movement was taking place, and afterward till the early hours of the 28th.

Fog.—There was practically no fog in February over the eastern half of the North Atlantic, which contrasts with the moderate amounts noted during the second half

of January to eastward and northeastward of the Azores. In the Grand Banks-St. Lawrence area there was about the same amount as during January, the 5°-square, 40° to 45° N., 45° to 50° W., having most February occurrences in this area, namely 5 days. On the whole, this area had slightly less fog than the average amount for February. To southward of Nova Scotia and near the east coast of New England, as had been the case in January, fog was very infrequent.

From Cape Cod to near Galveston, Tex., except in the vicinity of Florida, Georgia, and South Carolina, fog was considerably more frequent than normally in February. Two squares stand out conspicuously for their numerous reports. The square 35° to 40° N., 70° to 75° W., experienced fog on 9 days, well scattered through the month; while in the Gulf of Mexico the square 25° to 30° N., 90° to 95° W., had fog on no less than 12 days, almost all during the first half of the month.

OCEAN GALES AND STORMS, FEBRUARY 1938

Vessel	Voyage		Position at time of lowest barometer		Gale began February—	Time of lowest barometer February—	Gale ended February—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Tennessee, Dan. S. S.	New York	Oslo	50 02 N.	41 23 W.	1	Mdt, 1	2	30.12	SW	SW, —	W	W, 10	SW-W.
American Importer, Am. S. S.	Belfast	Boston	55 06 N.	19 07 W.	2	4p, 3	5	29.67	W	WSW, 8	WNW	WNW, 9	SW-W.
Fairfield City, Am. S. S.	Gibraltar	do	41 30 N.	53 45 W.	4	Mdt, 4	5	29.99	SSE	SSW, 9	N	SSW, 10	S-W.
Black Gull, Am. S. S.	Antwerp	New York	47 06 N.	40 00 W.	5	4p, 5	6	29.65	SSW	SW, 9	WNW	SW, 10	SSW-W.
Svanhild, Dan. S. S.	Swansea	Boston	50 08 N.	38 44 W.	5	5p, 5	6	[1]29.41	WSW	SW, 11	NNW	SW, 11	SSW-W.
American Importer, Am. S. S.	Belfast	do	52 21 N.	34 41 W.	5	4a, 6	7	29.31	SSW	WSW, 7	WSW	SW, 10	SW-NW.
Irisbank, Br. M. S.	Durban	do	36 39 N.	62 00 W.	7	Mdt, 7	9	29.83	SW	SW, 10	NW	NW, 10	SSW-NW.
Saturnia, Ital. M. S.	Lisbon	New York	38 09 N.	55 00 W.	7	11a, 8	9	29.57	S	SW, 8	NNW	SW, 9	SSW-NNW.
Santa Rosa, Am. S. S.	Porto Cabello	San Juan	11 30 N.	68 15 W.	9	2a, 9	10	29.90	E	ENE, 7	NE	ENE, 8	E-NE.
Cyrus Field, Br. S. S.	Cable grounds out from Halifax.		[2]44 57 N.	58 34 W.	10	8p, 10	11	29.11	NW	NW, 8	WNW	NW, 10	S-NW.
Pres. Harding, Am. S. S.	Cobh	New York	42 37 N.	54 01 W.	10	8p, 10	11	29.22	S	S, 11	NNW	S, 11	S-W.
Arundo, Du. S. S.	Rotterdam	New Orleans	[2]35 30 N.	38 49 W.	10	Mdt, 10	10	[1]29.61	SE	NW, 4	SE	SE, 10	S-NW.
Svanhild, Dan. S. S.	Swansea	Boston	45 48 N.	56 54 W.	11	2a, 11	12	[1]28.78	WNW	WNW, 11	NW	WNW, 11	SW-WNW.
Sagaporack, Am. S. S.	Copenhagen	Philadelphia	[2]49 03 N.	48 46 W.	11	4p, 11	12	29.17	SSW	SSW, 9	SW	SSW, 10	ESE-SSW.
Tahoe, U. S. C. G.	Ice patrol out from Halifax.		[2]44 57 N.	48 34 W.	17	4a, 18	18	29.00	N	NNW, 10	WNW	NNW, 10	NNW-W.
American Trader, Am. S. S.	London	Boston	[2]44 26 N.	48 43 W.	17	6a, 18	18	28.75	NNE	WNW, 8	W	NW, 10	WNW-W.
Azalea City, Am. S. S.	Pensacola	do	42 00 N.	51 55 W.	17	10 p, 18	18	29.15	NE	NW, 10	NNW	NW, 10	
West Kyska, Am. S. S.	Antwerp	Tampa	31 47 N.	49 07 W.	19	Noon, 19	20	29.36	WNW	WNW, 10	NW	WNW, 10	
Dixie Arrow, Am. S. S.	Grangemouth	Magpetco	[2]32 16 N.	46 12 W.	19	1p, 19	19	29.30	W	WNW, 8	NW	WNW, 9	W-WNW.
Colytto, Du. S. S.	Rotterdam	Galveston	[2]34 49 N.	42 06 W.	19	7p, 19	20	29.15	NW	WNW, 6	WNW	NW, 9	WNW-NW.
West Tacook, Am. S. S.	Gibraltar	New Orleans	31 50 N.	35 00 W.	19	11p, 19	20	29.13	SW	SSW, 8	WNW	WNW, 9	SSW-WNW.
Clara, Ital. S. S.	do	New York	32 20 N.	37 55 W.	20	1a, 20	20	29.17	SW	SW, —	WNW	W, 11	SW-W.
Chateau Thierry, U. S. A. T.	Cristobal	do	37 25 N.	74 23 W.	20	Noon, 20	20	29.47	W	W, 9	N	W, 9	W-SW.
Exminster, Am. S. S.	Gibraltar	do	35 50 N.	31 10 W.	20	6p, 20	21	28.91	S	WSW, 5	W	W, 11	SW-WNW.
West Cohas, Am. S. S.	New Orleans	Liverpool	38 50 N.	63 00 W.	21	3a, 21	23	29.29	NNW	NE, 9	N	NNE, 10	NNW-NE NNE.
Sundance, Am. S. S.	Savannah	London	38 10 N.	62 45 W.	21	7a, 21	23	29.29	var	NE, 10	N	NE, 11	E-N.
Exchange, Am. S. S.	Djidjilli	New York	35 44 N.	57 11 W.	21	Noon, 21	21	29.31	SW	W, 8	NNE	N, 9	WSN-N.
Pres. Van Buren, Am. S. S.	Gibraltar	do	43 13 N.	47 06 W.	22	4a, 22	23	29.28	NE	NE, 7	N	NNW, 12	NE-NNW.
Boston City, Br. S. S.	Huelva	Philadelphia	36 11 N.	35 30 W.	22	Mdt, 22	24	28.97	WSW	SW, 10	NNW	SW, 11	WSW-SW.
Exminster, Am. S. S.	Gibraltar	New York	34 00 N.	36 34 W.	22	2a, 23	24	29.21	W	W, 10	W	W, 10	W-WSW.
Vulcania, Ital. M. S.	Boston	Lisbon	39 17 N.	36 09 W.	23	3a, 23	23	28.38	SSW	SW, 7	SW	SW, 10	Steady.
Victolite, Br. M. S.	Havre	Guiria	[2]40 01 N.	32 28 W.	21	1p, 23	24	28.68	SE	SSW, 9	SW	S, 10	SW-S.
Circe Shell, Br. M. S.	Curacao	Stockholm	[2]27 26 N.	45 57 W.	23	4p, 23	24	29.84	NW	WNW, 7	NW	NW, 8	
Loosdrecht, Du. M. S.	do	Liverpool	36 34 N.	44 45 W.	21	5p, 23	24	29.20	WSW	WNW, 9	NNW	NW, 10	WNW-NW.
Sarcoxie, Am. S. S.	Havre	New York	45 50 N.	28 00 W.	22	6a, 24	25	28.82	SE	S, 10	NNW	S, 10	SE-SSW.
Dordrecht, Du. M. S.	New York	Liverpool	42 06 N.	51 00 W.	24	8p, 25	25	29.24	SSW	SW, 5	SW	SW, 9	SW-NW.
Scottish Musician, Br. M. S.	Hamburg	Bermuda	32 08 N.	64 09 W.	25	6a, 26	26	29.41	SW	SSW, 9	W	SSW, 9	SSW-NW.
Sundance, Am. S. S.	Savannah	London	44 05 N.	42 48 W.	26	10a, 26	27	29.20	SW	SW, 7	W	WSW, 10	SW-WSW.
Excambion, Am. S. S.	Gibraltar	Boston	40 12 N.	47 12 W.	25	9p, 26	26	29.51	SW	S, 5	SSW	SSW, 10	
Dordrecht, Du. M. S.	New York	Liverpool	44 50 N.	44 00 W.	26	6a, 27	27	29.05	SE	SSW, 9	W	WSW, 10	S-WSW.
West Cohas, Am. S. S.	New Orleans	do	44 51 N.	43 00 W.	26	7a, 27	27	29.13	SSE	SSW, 11	WNW	SSW, 11	SSE-WSW.
Washington, Am. S. S.	Cobh	New York	[2]49 52 N.	27 04 W.	27	10p, 27	28	29.43	S	S, 9	W	SW, 10	S-W.
Nebraskan, Am. S. S.	Cristobal	do	31 51 N.	78 01 W.	27	4a, 28	[3]1	29.72	W	NW, 9	WSW	NW, 9	W-NW.
NORTH PACIFIC OCEAN													
Kwanto Maru, Jap. M. S.	Los Angeles	Yokohama	37 56 N.	149 15 E.	[4]31	Noon, 31	[4]31	28.96	SE	SSW, 11	WNW	WSW, 11	S-WSW.
Marian Otis Chandler, Am. S. S.	Balboa	Honolulu	11 42 N.	94 42 W.	[4]31	6p, 31	1	29.80	N	N, 4	NNE	N, 8	N-NNE.
Eclipse, Br. S. S.	Yokohama	San Francisco	42 12 N.	157 00 E.	[4]31	6a, 1	1	[1]29.10	E	S, 11	SW	SSW, 12	SE-SSW.
Nankai Maru, Jap. M. S.	Los Angeles	Balboa	14 03 N.	95 00 W.	1	2p, 1	1	[1]29.85	NE	N, 7	N	N, 7	
Pres. Grant, Am. S. S.	Seattle	Yokohama	51 42 N.	143 36 W.	1	2a, 1	2	29.41	NNW	W, 4	NNW	N, 9	W-NNE.
Navigator, Am. M. S.	Out from San Diego.		9 20 N.	85 40 W.	[4]30	6a, 2	1	29.76	E	SW, 2		ENE, 8	
Djambi, Du. M. S.	Manila	Los Angeles	[2]35 14 N.	136 16 W.	3	2p, 3	3	29.96	WNW	NW, 8	WNW	NW, 8	None.
Lebec, Am. S. S.	Los Angeles	Manila	32 34 N.	173 40 E.	6	1a, 6	8	[1]29.64	W	W, 6	NW	NW, 8	S-W-NW.
Nojima Maru, Jap. M. S.	Balboa	Los Angeles	14 12 N.	94 54 W.	7	6p, 7	7	29.90	N	N, 6	NE	NNE, 7	
Pres. Jefferson, Am. S. S.	Yokohama	Victoria, B. C.	42 06 N.	154 00 E.	7	10p, 7	7	29.64	WSW	W, 7	WSW	WSW, 8	
Pres. Grant, Am. S. S.	Seattle	Yokohama	48 00 N.	167 08 E.	7	8p, 7	8	29.60	SSE	SSE, 8	SSE	SSE, 8	None.
Fujisan Maru, Jap. M. S.	Los Angeles	Kure	33 10 N.	172 48 W.	8	Noon, 8	8	[1]29.51	S	S, 8	SSW	S, 8	S-W.
Pres. Grant, Am. S. S.	Seattle	Yokohama	42 15 N.	150 16 E.	10	4a, 10	10	29.42	NNW	NNW, 8	NNW	NNW, 8	NNE-NNW.
Manukai, Am. S. S.	San Francisco	Honolulu	[2]36 43 N.	126 03 W.	10	4a, 9	10	29.35	NW	NNW, 6	NW	NW, 8	ESE-NNW.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver, B.C.	41 24 N.	153 00 E.	10	10p, 10	12	29.40	NW	NW, 8	NW	NW, 8	
Kinai Maru, Jap. M. S.	Los Angeles	Yokohama	41 05 N.	135 00 W.	11	4p, 12	13	29.55	W	WNW, 8	WNW	WNW, 9	None.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver, B.C.	46 42 N.	171 30 E.	13	11a, 13	13	29.10	SE	SE, 9		SSE, 10	SE-SSE.
Pres. Taft, Am. S. S.	do	Honolulu	34 54 N.	140 18 E.	14	9p, 14	16	29.18	WNW	NW, 2	N	NW, 10	
Fujisan Maru, Jap. M. S.	Los Angeles	Kure	32 40 N.	153 19 E.	15	8a, 15	16	[1]29.28	S	SSW, 8	NW	WSW, 9	S-WSW.
Empress of Japan, Br. S. S.	Yokohama	Honolulu	35 01 N.	143 22 E.	15	Noon, 15	16	29.60	WNW	NW, 10	N	NW, 10	WNW-NW.
San Clemente Maru, Jap. M. S.	Lo Angeles	Kure	33 09 N.	150 05 E.	15	4a, 15	16	29.33	WSW	SSW, 7	NNW	W, 9	SSW-WSW.

[1] Barometer uncorrected. [2] Position approximate. [3] March. [4] January.

OCEAN GALES AND STORMS, FEBRUARY 1938—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began February—	Time of lowest barometer February—	Gale ended February—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH PACIFIC OCEAN			° ′	° ′				Inches					
Kinai Maru, Jap. M. S.	Los Angeles	Yokohama	46 30 N.	157 50 W.	15	8p, 15	16	28.57	S	SW, 10	WNW	W, 11	S-W.
Pres. Coolidge, Am. S. S.	Honolulu	do	33 34 N.	165 11 E.	16	6p, 16	17	28.99	SW	SW, 7	N	W, 12	SW-N.
California, Am. S. S.	Los Angeles	do	31 23 N.	179 44 W.	16	11a, 16	18	29.48	S	S, 7	W	SW, 8	S-SW
Nako Maru, Jap. M. S.	Yokohama	Los Angeles	45 02 N.	155 10 W.	18	10a, 18	19	28.94	SSE	SSE, 8	SW	SW, 9	SE-SSW.
Fujisan Maru, Jap. M. S.	Los Angeles	Kure	33 00 N.	145 00 E.	17	3p, 17	18	[1] 29.20	S	SW, 8	W	W, 10	S-W.
Sanyo Maru, Jap. M. S.	Yokohama	Los Angeles	41 25 N.	153 51 E.	17	10a, 18	18	29.02	SE	ESE, 9	NW	ESE, 9	
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	49 52 N.	129 23 W.	19	4a, 20	20	29.69	SE	SW, 4	S	SSE, 8	SE-SW.
Sanyo Maru, Jap. M. S.	Yokohama	Los Angeles	46 33 N.	175 50 W.	21	8p, 21	22	28.83	E	ENE, 9	NE	ENE, 9	2 points.
California, Am. S. S.	Los Angeles	Yokohama	31 47 N.	157 30 E.	21	2p, 21	22	29.33	W	W, 8	W	W, 9	
Kongo Maru, Jap. M. S.	Yokohama	Los Angeles	43 06 N.	162 42 E.	21	10p, 22	22	29.02	NW	NW, 5	NW	NW, 8	NW-S.
Toho Maru, Jap. M. S.	Kure	do	36 00 N.	162 00 E.	21	10p, 21	22	29.17		W, 8		W, 8	
Empress of Japan, Br. S. S.	Honolulu	Victoria, B. C.	33 21 N.	146 46 W.	22	Noon, 23	23	29.49	S	S, 8	SW	S, 9	
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	51 57 N.	161 43 W.	22	4a, 23	24	28.66	E	ENE, 6	NNE	NNE, 8	E-NE.
City of Dalhart, Am. M. S.	Los Angeles	Honolulu	30 18 N.	134 46 W.	26	1p, 26	26	29.52	SSW	SSW, 8	WSW	SSW, 8	S-WSW.
Do	do	do	28 50 N.	139 44 W.	27	5p, 27	27	29.46	S	SW, 8	WNW	SSW, 9	S-WSW.
Lurline, Am. S. S.	Honolulu	San Francisco	30 08 N.	142 36 W.	28	6p, 28	28	29.46	SSW	SSW, 8	SW	SSW, 8	SSW-SW.
Pres. Taft, Am. S. S.	do	do	36 36 N.	127 06 W.	28	4p, 28	28	29.37	SE	SW, 8	SW	SW, 8	SE-SW.
Pres. McKinley, Am. S. S.	Yokohama	Victoria, B. C.	49 59 N.	159 55 W.	27	6p, 28	28	28.85	NNW	NW, 7	NW	NW, 10	

[1] Barometer uncorrected.

NORTH PACIFIC OCEAN, FEBRUARY 1938

By WILLIS E. HURD

Atmospheric pressure.—Extensive low-pressure areas lay along the northern steamer routes of the Pacific throughout February 1938. The average center of the Aleutian cyclone was in consequence shifted to the southward and eastward of its normal position over the Aleutians, and extended to the north from the western part of the Gulf of Alaska (Kodiak, 29.67 inches) southwestward and then westward below the Aleutians well toward the Kuril Islands. Pressures over the eastern Aleutians and the Bering Sea, as shown by Dutch Harbor (29.79 inches) and St. Paul (29.91 inches), were 0.19 and 0.26 inch, respectively, higher than the normal. Thence northward anticyclonic conditions continued into the Arctic Ocean.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, February 1938*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Point Barrow	30.22	+0.10	30.82	18	29.52	25
Dutch Harbor	29.79	+.19	30.52	2	29.04	23
St. Paul	29.91	+.26	30.56	2	29.16	28
Kodiak	29.67	+.05	30.38	9	28.86	23
Juneau	29.91	−.01	30.39	15	29.48	3
Tatoosh Island	29.83	−.17	30.38	24	29.18	3
San Francisco	30.00	−.10	30.32	6	29.25	9
Mazatlan	29.95	+.02	30.00	2, 27	29.88	21
Honolulu	29.93	−.12	30.10	15	29.76	26
Midway Island	29.84	−.15	30.10	3	29.22	8
Guam	29.85	−.06	29.97	25	29.53	13
Manila	29.90	+.01	30.03	22	29.83	14, 16, 18
Hong Kong	30.03	−.03	30.29	22, 24	29.68	15
Naha	30.06	+.01	30.30	21, 24	29.74	15
Titijima	29.98	.00	30.24	26-28	29.77	17
Tokyo	29.92	-------	30.24	28	29.38	17

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

In lower midocean and in coastal waters of the United States, average pressures were unusually low for the month, owing to the southward and eastward extension and persistence of LOWS. At Tatoosh Island the average pressure, 29.83 inches, was subnormal by 0.17 inch. At Midway Island, the average barometer, 29.84, was lower than the normal by 0.15 inch, and was also the lowest average reading of record for the period 1916–38. Here daily readings above normal occurred on only 6 days. Even as far south as Honolulu pressure was as much as 0.12 inch below the normal. The lowest pressure reading of the month, 28.47, was reported by the Japanese motorship *Kunikawa Maru*, near 45° N., 149° W., on the 26th.

In Asiatic waters the usual anticyclone peculiar to February extended well eastward from the China coast. The eastern North Pacific HIGH, however, was weakly developed and on the average occupied only a small region lying southwest of southern California.

Cyclones and gales.—Throughout the month the northern and central waters of the North Pacific were traversed by LOWS, some of them of considerable depth. However, gales were of somewhat less frequency and severity than in the previous January. The ocean as a whole cannot be classed as particularly stormy. In two sections, however, gales were more frequent than eleswhere; one, extending from the eastward of Japan nearly to Midway Island, and the other southwest of California. Along most of the central and eastern parts of the northern routes gales were few and scattered with only one instance reported of a wind as strong as force 11. This was encountered by the Japanese motorship *Kinai Maru*, barometer 28.57, near 46° N., 158° W., on the 16th.

At the close of the preceding month the heaviest storminess occurred between Japan and longitude 150° E., with the highest wind-force, 11, reported by the Japanese motorship *Kwanto Maru* on the 31st, near 38° N., 149° E. On February 1 the place of greatest intensity in the storm region was near 42° N., 157° E. Here at noon the British steamer *Eclipse* encountered a southerly hurricane, preceded during the voyage from Yokohama to San Francisco by fresh to full gales since the afternoon of January 31.

The most important LOWS of the month economically were those that developed off the west coast of the United States during the period of the 1st to 14th. These LOWS were of less extent and depth than many others forming in the central and western Pacific, but they were the cause of much damage in coastal and inland localities of California, owing to strong winds and heavy rains with attendant

floods. At the Weather Bureau office, San Francisco, the maximum wind velocity for a 5-minute period was at the rate of 38 miles from the southwest, lowest barometer 29.25 on the 9th, but winds were reported by the press to have been much higher in the harbor. At Los Angeles on the same date the highest velocity was 26 miles from the east. Owing to heavy coastal seas there was some damage and loss to small shipping there. The strongest gales reported by ships a day or two out from west-coast ports of the United States during the period were of force 9, on the 1st, 12th, and 13th.

During the last week in February there was further stormy weather in the vicinity, but mostly midway along the San Francisco-Hawaii routes. The heaviest gale reported in this area and period was of force 9, barometer 29.46, experienced by the American motorship *City of Dalhart*, near 29° N., 140° W.

To the immediate northward of Midway Island the stormiest weather occurred on the 8th and 16th, but no gales were reported there in excess of force 8 on those dates. To the near westward of Midway fresh gales occurred on the 6th and 7th; but between longitude 170° E. and central Japan, latitudes 30° N. and 40° N., there was much stormy weather during the 15th to 22d, the winds being particularly strong on the 15th to 18th, with forces of 9 to 10 covering a considerable area from near Yokohama eastward. On the 16th the strongest gale of the region—of force 12 from the west—was encountered by the American steamer *President Coolidge* in 33°34′ N., 165°11′ E. Shortly afterward the ship's barometer fell to 28.99 inches, which is an unusually low reading in an extra-tropical cyclone of that low latitude.

Gales at the end of February so far as indicated by reports, were confined to localities west and southwest of California, where there were winds of force 8, and to the southeastward of the Aleutian Islands, where the American steamer *President McKinley*, near 50° N., 160° W., had a northwest wind of force 10 and a barometer down to 28.85.

Gales of Mexican-Central American waters.—Only 2 Tehuantepecers were reported in the month. These were of force 7 in the Gulf of Tehuantepec on the 1st and 7th, and of force 8 on the 1st at some distance to the south of the Gulf. Off the coast of Costa Rica a northeaster of force 8 occurred on the same date.

Fog.—There was considerably more fog observed on the ocean than during any preceding cold month of the season. Near the thirty-fifth parallel, to the northward of Midway Island, fog occurred on the 1st to 3d. Between about 40° and 50° N., 170° E. and 165° W., fog was seen on 10 days during the 1st to 11th. Along the belt, 38° to 42° N., 135° to 155° W., fog was reported on the 13th to 16th and on the 20th and 24th. Near the California coast it occurred on the 21st, 23d, and 24th; off Lower California, on the 7th; and near the Gulf of Tehuantepec on the 3d.

Waterspouts.—Five waterspouts, circulation clockwise, were reported by the American steamer *Tulsagas* on the 13th, in 45°49′ N., 124°18′ W. When observed, the ship had a south wind of force 7, barometer 29.41 inches (uncorrected). The weather was squally, with passing showers of rain and hail.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, February 1938*

[For description of tables and charts, see REVIEW, January, p. 27]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	55.5	+6.7	Greensboro	85	11	Haleyville	18	1	1.90	−3.31	Seven Hills	3.20	Hytop	0.61
Arizona	45.6	−.5	Benson	86	4	2 stations	−11	18	1.75	+.43	McNary	5.05	Ajo	.31
Arkansas	50.9	+7.3	Wilson	87	[1] 10	Gravette	8	1	6.08	+2.76	Devils Knob	10.79	Yancopin	2.37
California	45.7	−2.4	Palm Springs	89	25	Boca	−26	17	9.26	+4.74	Inskip	38.05	Greenland Ranch	.36
Colorado	30.5	+3.2	Lamar	76	12	Spicer	−30	18	.99	.00	Pagosa Springs (near).	10.78	Byers	.03
Florida	63.5	+2.9	2 stations	88	[1] 6	Mason	24	1	1.36	−1.79	DeFuniak Springs	4.38	Lake Placid	.00
Georgia	54.7	+6.1	Stillmore	84	14	2 stations	17	[1] 2	1.12	−3.71	Dalton	2.18	Fargo	.33
Idaho	31.3	+3.3	Bruneau	69	27	Warren	−29	16	1.82	+.09	Sun Valley	6.62	Mountain Home	T
Illinois	39.0	+9.3	Sparta	78	12	3 stations	4	1	2.41	+.50	Waterloo	4.93	Keithsburg	1.01
Indiana	39.2	+8.7	Shoals	83	13	Gary	2	1	2.82	+.41	Lafayette	4.38	2 stations	1.70
Iowa	29.0	+6.7	4 stations	71	[1] 5	Inwood (near)	−22	18	.94	−.15	Inwood (near)	2.33	Boone	.11
Kansas	37.7	+4.7	3 stations	80	[1] 11	2 stations	−5	19	1.16	+.16	Ashland	3.49	Sharon Springs	.06
Kentucky	45.7	+8.6	Princeton	77	12	Farmers	8	1	2.39	−.96	Mammoth Cave	4.11	Ravenna	1.29
Louisiana	59.1	+5.3	2 stations	84	14	3 stations	21	1	3.20	−1.32	Jonesville	6.30	Port Eads	1.09
Maryland-Delaware	38.9	+5.3	Western Port, Md.	76	18	Mount Savage Summit, Md.	4	28	2.53	−.42	Friendsville, Md.	3.97	Hancock, Md.	.90
Michigan	25.7	+5.5	Monroe	67	13	Iron Mountain	−39	1	3.20	+1.57	Lansing	7.47	Ironwood	.30
Minnesota	16.2	+3.7	Long Prairie	57	26	2 stations	−42	1	.78	+.03	Springfield	1.76	Alexandria	.06
Mississippi	56.1	+6.6	2 stations	84	[1] 10	Eupora	19	1	3.20	−1.64	Magnolia	5.40	Biloxi	1.43
Missouri	41.4	+8.3	Mount Vernon	80	13	Unionville	−5	1	3.20	+1.12	Willow Springs (near).	7.34	Bethany	T
Montana	18.3	−3.8	Billings No. 2	67	27	2 stations	−35	17	.67	−.02	Hebgen Dam	4.79	Harlowton (near)	T
Nebraska	28.6	+2.4	3 stations	75	12	Santee	−23	19	.64	−.06	Hartington	1.88	Chadron	.07
Nevada	34.8	+.9	2 stations	77	[1] 11	2 stations	−10	[1] 16	1.82	+.75	Marlette Lake	11.91	Mina	.18
New England	26.0	+3.4	Fitchburg, Mass.	57	6	do	−23	[1] 10	2.41	−.70	Lakeport, N. H.	4.33	Presque Isle, Maine	.88
New Jersey	35.5	+4.8	4 stations	70	[1] 14	Newton	6	28	2.31	−1.30	Burlington	3.90	Newark	1.78
New Mexico	38.4	+1.0	Lovington	83	11	Selsor Ranch	−23	18	.96	+.24	White Tail	3.65	Hillsboro	T
New York	27.5	+5.1	Fredonia	63	14	Whiteface Mountain	−22	28	3.00	+.32	High Market	6.82	Scotia	.74
North Carolina	48.0	+5.3	2 stations	81	14	Mount Mitchell	6	26	1.56	−2.45	Parker	4.26	Red Springs	.32
North Dakota	7.2	−2.4	Hettinger	60	28	Berthold Agency	−35	17	.68	+.22	Westhope	1.52	Rugby	.23
Ohio	37.4	+8.1	2 stations	73	13	Jefferson	1	1	2.87	+.27	Jefferson	4.39	Mineral Ridge	1.17
Oklahoma	46.4	+5.4	Buffalo	84	11	2 stations	−2	19	4.45	+3.08	Calvin	11.00	Goodwell	.23
Oregon	35.1	.0	Oakridge	78	26	Fremont	−22	17	4.56	+1.40	Brookings	18.77	Sheaville	.61
Pennsylvania	34.1	+5.8	Vandergrift	74	13	Kane	−4	[1] 1	2.85	.00	Bradford	5.33	Hyndman	.28
South Carolina	52.7	+5.3	Beaufort (near)	84	14	2 stations	19	[1] 2	.92	−3.32	Caesars Head	2.67	McColl	.26
South Dakota	18.6	−.5	Kennebec	71	11	do	−34	18	.60	+.04	Wagner	2.39	Hot Springs	.03
Tennessee	49.1	+7.9	Moscow	81	10	3 stations	11	1	2.49	−1.81	Memphis	5.88	Palmetto	1.09
Texas	55.6	+4.3	3 stations	88	[1] 12	2 stations	0	[1] 18	2.16	+.38	Honey Grove	7.90	San Benito	.03
Utah	33.1	+3.1	St. George	68	[1] 11	Woodruff	−20	18	1.44	+.16	Silver Lake	7.07	Mount Emmons	.15
Virginia	43.0	+5.8	Clarksville	79	14	Mountain Lake	5	1	1.65	−1.44	Mineral	2.90	Roanoke	.51
Washington	34.9	+.8	Centralia	75	27	Stockdill Ranch	−8	[1] 8	3.34	−.57	Wynoochee Oxbow	13.09	Wilson Creek	.60
West Virginia	40.9	+7.6	2 stations	76	19	3 stations	4	1	3.01	−.10	New Martinsville	5.85	McNeill	.64
Wisconsin	23.5	+6.5	do	59	13	Long Lake	−51	1	2.14	+.93	Oconto	4.67	Mellen	.25
Wyoming	24.6	+2.4	do	68	[1] 11	Fort Laramie (near)	−37	16	.51	−.27	Bechler River	3.87	Clark	T
Alaska (January)	.1	−1.8	Wrangell	54	8	Allakaket	−56	22	2.82	+.69	Little Port Walter	34.14	Teller	T
Hawaii	71.3	+2.8	Hakalau	89	24	Kanalohuluhulu	42	24	7.85	+.78	Honohina	21.50	2 stations	1.37
Puerto Rico	72.6	−1.7	Mayaguez	92	24	Cayey	47	19	3.57	+.42	Rio Blanco	12.44	Mona Island	.00

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, February 1938*

[Compiled by Annie E. Small, by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							28.4	+3.0										77	2.37	−0.9										6.4		
Eastport	76	67	85	30.06	30.15	+0.17	21.3	−0.2	41	6	29	−2	11	14	32	20	16	79	1.99	−1.4	13	12.5	nw.	32	e.	14	10	1	17	6.6	12.4	8.3
Greenville, Me.	1,069	4	41				15.0		37	22	26	−19	12	4	49				2.65		14	5.0			n.							
Portland, Me.	103	82	117	30.04	30.17	+.15	26.6	+2.8	46	7	34	5	11	19	27	24	19	74	4.11	+.1	14	8.8	n.	30	n.	10	11	5	12	5.4	12.1	5.3
Concord	289	54	72	29.84	30.17	+.13	26.8	+4.0	49	6	36	3	27	17	35				2.11	−.8	15	5.7	nw.	25	nw.	28	12	5	11	5.4	9.5	5.1
Burlington	403	11	48	29.73	30.20	+.17	22.1	+2.7	45	6	30	−5	11	14	35	19	17	83	1.64	+.1	15	11.2	s.	40	s.	5	3	10	15	7.1	5.6	1.7
Northfield	876	12	60	29.20	30.19	+.15	21.0	+4.6	49	6	31	−8	2	10	42	18	15	82	1.49	−.8	12	8.9	n.	27	s.	3	5	5	18	7.1	3.4	1.2
Boston [1]	29	33	62	30.12	30.15	+.11	30.6	+1.8	53	6	38	8	28	23	31	28	23	74	2.38	−1.0	16	11.6	nw.	37	nw.	28	6	7	15	7.0	10.0	1.5
Nantucket	12	14	90	30.13	30.14	+.10	33.4	+2.7	49	14	39	12	28	28	25	32	29	86	3.01	−.4	17	14.6	n.	51	ne.	20	5	6	17	7.4	3.8	.7
Block Island	26	11	46	30.13	30.16	+.10	33.5	+3.1	50	6	39	9	28	28	27	31	27	76	1.93	−1.7	15	16.3	nw.	49	nw.	28	9	6	13	6.1	.7	.5
Providence	159	215	251	29.98	30.16	+.11	31.8	+2.8	53	18	40	7	28	24	29	29	24	73	2.34	−1.3	15	11.9	nw.	41	nw.	28	11	2	15	5.9	11.6	2.4
Hartford	159	66	100	30.02	30.20	+.14	31.6	+4.4	50	6	39	6	28	24	29				2.20	−1.6	10	9.2	nw.	30	nw.	28	9	6	13	6.0	7.9	1.5
New Haven	106	74	153	30.08	30.20	+.13	33.2	+4.2	55	14	40	8	28	26	29	29	22	67	2.91	−1.1	12	9.5	n.	35	nw.	28	8	4	16	6.8	2.0	.6
Middle Atlantic States							38.2	+4.9										71	2.02	−1.2										7.1		
Albany	97	97	112	30.10	30.21	+.14	29.4	+5.3	50	6	37	2	28	22	30	26	20	68	1.60	−.9	15	8.7	nw.	23	s.	5	5	5	18	7.3	6.5	1.5
Binghamton	871	57	79	29.24	30.20	+.12	29.8	+5.8	58	14	39	2	28	21	40	27	25	86	2.34	+.1	17	7.4	nw.	27	nw.	28	0	6	22	8.9	2.3	.6
New York	314	415	454	29.84	30.19	+.11	35.6	+4.3	59	18	43	10	28	28	25	31	25	68	2.24	−1.6	11	15.6	nw.	60	nw.	28	6	6	16	6.9	T	.0
Harrisburg	374	94	104	29.79	30.21	+.12	35.0	+4.8	62	18	42	13	28	28	28	31	25	68	2.03	−.9	10	7.8	nw.	30	nw.	28	7	6	15	6.8	1.7	.0
Philadelphia	114	123	367	30.09	30.22	+.12	37.4	+3.5	65	18	45	15	28	30	31	33	26	66	2.54	−.8	10	13.6	sw.	39	nw.	28	6	8	14	6.6	4.1	.0
Reading	323	283	306	29.85	30.22		35.8	+7.0	66	18	44	12	28	28	28	32	26	69	1.77	−1.6	13	11.7	nw.	54	e.	19	5	8	15	7.0	3.2	T
Scranton	805	72	104	29.31	30.20	+.12	31.0	+3.7	58	18	39	7	28	23	32	28	22	69	2.82	−.2	12	7.4	nw.	30	nw.	28	3	10	15	7.5	3.3	.8
Atlantic City	52	37	172	30.14	30.20	+.09	38.8	+5.2	70	14	46	17	28	32	30	35	30	73	2.19	−1.2	10	17.0	nw.	53	ne.	20	6	8	14	6.5	.3	.0
Sandy Hook	22	10	57	30.17	30.19		35.5	+3.4	57	6	41	14	28	30	22	32	28	76	2.22	−1.5	11	15.2	nw.	52	nw.	28	6	6	16	6.7	.4	.0
Trenton	190	88	106	29.99	30.21		35.6	+4.9	64	18	44	13	28	28	31	32	26	69	2.17	−1.1	10	9.7	nw.	34	nw.	28	6	4	18	7.2	3.0	.0
Baltimore	123	100	215	30.08	30.22	+.11	40.4	+5.0	73	18	48	20	28	33	34	35	28	65	3.10	−.3	9	11.0	sw.	41	nw.	28	6	6	16	6.9	.6	.0
Washington	112	62	85	30.09	30.22	+.11	40.9	+5.6	71	18	49	21	28	33	29	35	28	65	2.37	−.9	9	7.9	s.	30	nw.	7	6	6	16	6.5	1.4	.0
Cape Henry	18	8	54	30.19	30.21		46.2	+5.0	75	6	54	24	17	39	31	41	37	76	1.56	−1.7	7	14.3	sw.	43	nw.	20	4	12	12	6.6	T	.0
Lynchburg	686	144	184	29.48	30.24	+.13	45.2	+4.9	74	14	54	20	2	36	32	39	32	67	1.16	−2.0	5	8.5	sw.	31	nw.	28	5	6	17	7.0	T	.0
Norfolk	91	80	125	30.13	30.23	+.12	46.8	+4.1	76	14	54	29	26	39	29	41	36	73	1.10	−2.1	7	11.3	ne.	34	w.	20	3	7	18	7.5	T	.0
Richmond	144	11	52	30.08	30.24	+.13	44.8	+5.2	75	14	54	24	2	35	31	39	34	73	1.89	−1.3	9	9.1	ne.	31	nw.	7	8	6	14	6.3	T	.0
Wytheville	2,304	49	55	27.77	30.22	+.10	40.8	+5.7	65	6	50	18	1	32	36	36	33	79	1.18	−1.8	11	7.8	w.	25	w.	27	3	5	20	7.8	.7	.0
South Atlantic States							52.6	+4.7										74	0.93	−2.8										5.9		
Asheville	2,253	89	104	27.84	30.25	+.12	44.8	+6.3	71	6	54	22	1	36	35	40	36	76	1.04	−2.1	11	9.9	nw.	27	nw.	27	4	7	17	7.5	.2	.0
Charlotte	779	68	86	29.38	30.24	+.12	49.2	+5.3	76	10	58	28	1	40	28	42	36	65	.66	−3.5	5	7.8	ne.	30	sw.	19	5	9	14	6.6	T	.0
Greensboro [1]	886	6	56	29.28	30.26		44.6		74	10	54	22	2	35	39	35	76		.98		9	8.4	ne.	28	sw.	19	4	7	17	7.3	T	.0
Hatteras	11	5	50	30.20	30.22	+.11	50.0	+2.6	71	6	56	34	26	44	23	46	44	84	1.81	−2.2	6	14.9	n.	40	n.	20	9	10	9	5.3	.0	.0
Raleigh	366	103	140	29.81	30.23	+.12	49.1	+5.9	78	14	58	26	2	40	29	43	38	72	.87	−3.0	9	9.6	sw.	28	nw.	7	7	8	13	5.9	T	.0
Wilmington	72	73	107	30.16	30.24	+.12	52.1	+4.2	77	14	61	29	26	43	28	46	42	76	.93	−2.3	7	9.6	ne.	30	sw.	19	9	6	13	5.9	T	.0
Charleston	48	11	92	30.18	30.23	+.11	55.3	+2.9	79	14	62	34	26	48	24	50	46	78	.76	−2.2	8	10.6	ne.	24	ne.	1	9	5	14	6.0	.0	.0
Columbia, S. C.	347	70	91	29.85	30.24	+.13	54.0	+5.8	78	14	64	33	26	44	33	46	39	63	.49	−3.3	4	8.8	ne.	24	s.	19	12	5	11	5.1	T	.0
Greenville, S. C.	1,039	139					48.6	+5.3	78	10	57	29	2	40	36			70	1.15	−4.0	7						8	7	13			.0	.0
Augusta	182	62	77	30.02	30.21	+.09	55.4	+5.5	79	14	66	32	26	45	35	48	41	66	.52	−3.6	5	6.5	nw.	22	sw.	19	8	11	9	5.2	.0	.0
Savannah	65	73	152	30.15	30.22	+.10	58.2	+4.2	80	14	67	32	26	49	29	51	47	77	.54	−2.6	5	11.2	e.	29	nw.	25	12	5	11	5.5	.0	.0
Jacksonville	43	86	110	30.17	30.22	+.10	51.6	+3.6	81	14	70	37	26	53	27	55	52	81	1.41	−1.6	7	8.6	ne.	26	sw.	26	12	7	9	5.1	.0	.0
Florida Peninsula							68.3	+2.9										77	0.94	−1.2										3.2		
Key West	21	10	64	30.12	30.14	+.07	72.1	+1.6	82	23	77	60	26	67	13	65	63	80	.25	−1.1	3	11.6	e.	24	nw.	24	18	9	1	3.0	.0	.0
Miami	25	124	168	30.13	30.16	+.06	70.2	+3.1	80	20	75	45	26	65	21	63	60	74	1.15	−.7	9	10.3	ne.	25	ne.	8	14	12	2	3.6	.0	.0
Tampa	35	88	197	30.15	30.19	+.09	66.4	+4.5	83	6	75	43	26	57	28	58	55	77	.85	−1.7	3	11.6	e.	25	ne.	2	16	9	3	3.1	.0	.0
Titusville	43	5	36	30.13	30.18		64.4	+2.3	82	7	76	34	26	53	30	57	56		1.52	−1.2	7		e.				12	12	4		.0	.0
East Gulf States							56.6	+5.0										75	1.66	−3.1										5.4		
Atlanta [1]	976	5	53	29.18	30.22	+.10	51.4	+6.1	75	14	62	28	1	41	31	44	40	73	1.18	−3.6	5	9.9	nw.	33	sw.	19	9	8	11	5.5	.0	.0
Macon	370	79	87	29.82	30.23	+.11	55.2	+5.9	79	14	66	30	26	44	34	48	43	71	.86	−3.6	5	7.6	nw.	22	s.	19	9	13	6	4.7	.0	.0
Thomasville	273	49	58	29.92	30.22	+.10	59.4	+4.4	80	15	70	34	25	49	32	52	49		1.23	−3.2	6		e.								.0	.0
Apalachicola	35	11		30.17	30.21		58.9	+2.6	71	16	66	40	21	52	23	54	52	84	.38	−3.5	2	8.9	e.	26	e.	17	12	6	10	5.0	.0	.0
Pensacola	56	149	185	30.16	30.22	+.11	57.2	+2.0	74	7	64	28	1	51	32	54	50	82	1.72	−2.6	4	11.2	se.	30	w.	26	12	10	6	4.5	.0	.0
Anniston	741	9					53.2	+7.4	77	11	64	22	1	43	35				2.23	−3.2	5		nw.				11	9	8		.0	.0
Birmingham	700	11	48	29.46	30.21	+.09	54.6	+6.6	78	10	64	23	1	45	34	47	42	71	1.65	−3.4	6	8.2	se.	24	se.	17	10	8	10	5.7	.0	.0
Mobile	57	86	161	30.16	30.22	+.11	58.6	+3.9	77	10	68	28	1	49	32	52	49	79	1.88	−3.4	4	9.4	s.	24	w.	26	9	10	9	5.3	.0	.0
Montgomery	218	92	105	29.98	30.23	+.11	56.9	+5.3	77	10	67	29	1	47	33	50	44	69	1.32	−4.1	4	7.8	e.	28	nw.	18	13	6	9	4.9	.0	.0
Meridian	375	67	92	29.81	30.21	+.10	56.2	+6.6	78	10	66	24	1	46	35	49	44	73	2.27	−3.2	6	6.7	s.	21	sw.	26	9	12	7	5.3	.0	.0
Vicksburg	247	82	102	29.93	30.20	+.10	57.3	+5.5	78	13	66	24	1	49	31	51	45	71	3.68	−1.1	4	9.5	se.	24	w.	19	5	8	15	7.0	.0	.0
New Orleans	53	76	84	30.16	30.21	+.12	60.8	+3.5	81	14	69	31	1	52	22	55	52	79	1.50	−2.8	6	7.4	se.	18	e.	22	6	12	10	5.8	.0	.0
West Gulf States							57.3	+5.7										76	3.39	+0.9										6.6		
Shreveport	249	92	227	29.92	30.20	+.11	57.9	+7.0	80	17	67	25	1	49	34	51	46	71	2.38	−.9	5	12.2	s.	34	s.	17	7	7	14	6.4	.0	.0
Bentonville	1,303	12	38	28.81	30.20	+.10	46.0	+7.5	73	11	54	17	19	38	29				7.33	+5.2	10	8.6	sw.	27	se.	14	2	12	14		2.5	.0
Fort Smith	463	57	82	29.70	30.19	+.09	49.6	+6.8	75	10	58	22	19	42	31	45	40	74	9.21	+6.6	9	9.7	e.	31	e.	15	6	8	14	6.7	.4	.0
Little Rock	357	94	102	29.81	30.20	+.09	51.0	+6.1	77	10	59	21	1	43	29	46	41	73	4.87	+1.0	8	9.1	s.	24	sw.	18	5	7	16	7.0	T	.0
Austin	605	68	90	29.50	30.14		59.2	+5.8	81	27	68	24	1	51	34	54	49	74	2.72	+.4	6	8.7	s.	24	nw.	18	7	8	13	6.3	.0	.0
Brownsville	57	88	96	30.04	30.10		66.4	+3.8	80	28	74	40	1	59	28	61	59	82	.06	−1.2	3	11.2	se.	27	s.	15	4	14	10	6.5	.0	.0
Corpus Christi	20	11	78	30.11	30.13	+.08	63.8	+5.4	76	27	69	40	1	58	22	60	58	85	1.74	+.3	5	11.9	se.	34	e.	21	4	10	14	6.8	.0	.0
Dallas	512	220	227	29.60	30.16		54.2		76	11	62	27	1	46	29	49	44	73	4.73	+2.4	7	12.4	se.	38	w.	18	3	10	15	7.2	2.9	.0
Fort Worth	679	92	110	29.44	30.16	+.09	54.3	+6.0	77	11	63	26	1	46	30				4.57	+2.8	5	10.0	s.	25	n.	6	9	7	12	6.0	3.1	.0
Galveston	54	106	114	30.12	30.18	+.11	59.4	+3.1	72	27	65	37	1	54	21	56	54	88	1.91	−.9	6	11.2	se.	30	se.	17	8	8	12	6.1	.0	.0
Houston	138	292	314	30.03	30.18		61.0	+5.1	78	9	69	29	1	53	30				3.74	+.6	7	12.3	se.	30	s.	17	5	8	15	6.7	.0	.0
Palestine	510	64	72	29.64	30.18	+.10	57.6	+6.4	77	14	66	25	1	49	28	51	46	72	1.93	−1.1	6	8.9	s.	25	s.	17	4	11	13	6.8	.0	.0
Port Arthur	34	98	106	30.15	30.19		60.0		77	27	67	30	1	53	28				1.94	−1.6	5	13.2	se.	38	s.	18	7	8	13	6.3	.0	.0
San Antonio	693	242	301	29.41	30.13	+.08	61.3	+5.9	82	27	70	28	1	53	32	55	50	70	.33	−1.3	6	12.7	se.	36	se.	16	5	6	17	6.9	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, February 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind[1]: Average hourly velocity	Wind[1]: Prevailing direction	Wind[1]: Maximum velocity: Miles per hour	Wind[1]: Maximum velocity: Direction	Wind[1]: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*°F.*		*°F.*	*° F.*		*° F.*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							43.3	+7.2										75	2.73	−0.6										7.7		
Chattanooga	762	71	214	29.40	30.23	+0.10	51.8	+7.7	76	12	60	28	1	43	29	45	39	67	1.43	−3.4	8	9.3	s.	30	sw.	19	7	8	13	6.4	T	0.0
Knoxville	995	66	84	29.14	30.22	+.10	49.2	+7.3	74	12	58	26	1	41	31	44	39	72	2.55	−2.0	12	6.5	w.	27	sw.	19	6	8	14	6.2	T	.0
Memphis	399	78	86	29.76	30.20	+.09	51.6	+7.3	76	10	59	23	1	44	24	46	41	70	5.88	+1.5	8	9.1	s.	26	sw.	19	6	7	15	6.6	T	.0
Nashville	546	168	188	29.63	30.23	+.11	49.7	+8.1	74	12	57	20	1	42	26	45	40	72	1.82	−2.3	11	10.6	sw.	34	sw.	18	5	4	19	7.3	T	.0
Lexington	989	6																													
Louisville	525	188	234	29.62	30.22	+.11	44.2	+7.0	73	12	52	18	1	36	28	40	36	75	2.16	−1.4	14	12.2	s.	30	nw.	27	3	8	17	7.7	T	.0
Evansville	431	76	116	29.72	30.20	+.09	45.4	+9.1	72	12	53	18	1	38	26	41	37	74	2.71	−.5	12	11.1	n.	32	sw.	5	3	6	19	7.5	0.1	.0
Indianapolis	822	194	230	29.29	30.20	+.10	37.7	+6.6	67	13	45	13	1	30	25	35	31	76	2.52	−.2	12	12.6	s.	36	w.	6	1	6	21	8.6	2.0	.0
Terre Haute	575	63	149	29.54	30.17		40.3		70	12	48	13	1	33	25	37	34	78	2.65	.0	13	11.5	sw.	32	nw.	6	1	8	19	8.2	2.0	.0
Cincinnati	627	11	51	29.51	30.21	+.11	40.5	+7.7	71	13	48	15	1	33	33	37	33	78	2.25	−.7	14	9.3	sw.	24	nw.	27	2	4	22	8.4	1.1	.0
Columbus	822	90	210	29.30	30.20	+.11	38.1	+7.4	68	13	46	13	1	31	34	35	31	77	2.73	+.1	14	10.9	s.	29	w.	6	2	8	18	7.9	3.4	.0
Dayton	899	60	163	29.20	30.19		38.8	+7.4	70	13	46	13	1	31	36				2.75	+.1	10	10.1	sw.	27	sw.	13	1	6	21	8.5	3.7	.0
Elkins	1,947	65	83	28.11	30.23	+.13	39.1	+7.5	68	18	49	11	1	29	41	35	31	77	3.48	+.4	16	7.3	w.	30	w.	6	1	6	21	8.5	13.4	3.0
Parkersburg	637	77	84	29.50	30.20	+.10	41.0	+6.8	70	13	50	14	1	32	34	37	33	77	2.45	−.7	15	7.4	nw.	25	w.	6	2	5	21	8.2	1.1	.0
Pittsburgh[1]	1,273	39	54	28.79	30.19	+.10	36.2	+3.9	66	13	44	11	1	28	34	32	29	78	2.82	+.2	16	11.5	nw.	33	w.	7	1	7	20	8.4	3.4	1.0
Lower Lake Region							30.2	+5.1										80	3.34	+0.9									8.3		
Buffalo	768	243	280	29.32	30.18	+.12	28.5	+4.2	55	5	36	0	28	21	31	27	24	81	4.23	+1.3	18	15.2	sw.	35	sw.	3	3	4	21	8.3	9.8	4.1
Canton	448	10	61	29.69	30.20		20.5	+2.5	45	6	29	−9	28	12	34	19	18	90	3.28	+1.0	17	8.3	w.	28	e.	20	4	7	17	7.4	10.7	5.4
Ithaca	836	77	100	29.25	30.19		28.9	+4.4	57	13	38	2	28	20	40	26	22	79	2.16	+.2	19	11.7	nw.	34	se.	3	1	5	22	8.8	13.2	5.5
Oswego	335	71	85	29.80	30.18	+.12	27.9	+4.0	53	6	35	0	28	21	31	26	21	73	3.33	+.6	16	11.4	se.	34	n.	27	2	3	23	8.6	7.5	4.9
Rochester	523	86	102	29.60	30.20	+.14	29.6	+5.0	55	6	37	3	28	22	36	26	21	72	3.05	+.4	18	9.0	sw.	23	w.	14	4	3	21	8.1	14.9	5.0
Syracuse	596	65	79	29.54	30.21	+.14	29.6	+5.5	57	14	38	−1	28	22	42				2.56	−.2	20	7.9	s.	24	nw.	27	2	5	21	8.4	11.7	2.0
Erie	714	130	166	29.39	30.19	+.12	31.5	+4.6	62	13	39	5	28	24	37	30	26	79	4.12	+1.5	15	14.1	w.	38	se.	3	2	7	19	8.1	2.0	.2
Cleveland	762	267	318	29.33	30.18	+.11	33.8	+6.4	68	13	41	9	1	26	29	32	29	81	3.01	+.5	14	17.0	s.	47	nw.	27	4	1	23	8.5	2.0	T
Sandusky	629	5	67	29.49	30.16	+.09	34.5	+7.1	68	13	41	12	1	28	27				3.25	+1.1	14	10.5	sw.	26	nw	14	1	7	20	8.4	2.9	.0
Toledo	628	79	87	29.50	30.20	+.13	33.0	+5.7	66	13	40	9	1	26	28	31	28	80	3.39	+1.3	14	10.7	w.	30	w.	6	2	5	21	8.1	12.8	1.7
Fort Wayne	857	69	84	29.24	30.19		33.9	+6.3	65	13	41	11	1	27	25	32	29	82	2.77	+.4	15	10.5	nw.	30	w.	6	1	6	21	8.4	6.2	T
Detroit[1]	626	5	78	29.48	30.19	+.13	31.2	+5.9	63	13	38	4	1	24	25	29	26	80	4.95	+2.8	15	11.1	nw.	29	w.	6	2	2	24	8.6	4.8	T
Upper Lake Region							25.5	+6.5										83	3.12	+1.3									8.2		
Alpena	609	13	89	29.51	30.21	+.18	22.7	+4.7	45	8	29	−9	1	16	27	22	19	83	2.93	+1.2	16	10.9	nw.	32	se.	5	0	10	18	8.0	10.2	2.0
Escanaba	612	41	49	29.53	30.23	+.17	22.2	+6.8	41	27	30	−23	1	15	31	20	17	82	2.23	+.7	13	10.9	n.	42	n.	27	2	4	22	8.4	22.7	21.9
Grand Rapids	707	70	244	29.40	30.20	+.15	30.6	+6.9	58	13	37	5	1	24	22	28	25	81	5.30	+3.1	13	12.0	ne.	35	sw.	6	1	6	21	8.5	6.9	.6
Lansing	878	5	90	29.21	30.18		29.5	+6.6	57	13	36	3	1	23	25	28	26	86	7.47	+5.6	15	9.9	nw.	26	nw.	27	2	4	22	8.8	10.5	2.0
Ludington	637	5	54	29.47	30.19		27.4	+4.9	45	6	33	2	1	21	23	26	23		3.78	+1.8	16		e.				1	5	22		5.4	.9
Marquette	734	44	69	29.39	30.23	+.18	22.6	+6.3	45	26	29	−12	1	16	29	21	19	86	1.52	−.4	16	8.2	nw.	27	sw.	7	0	6	22	8.7	12.2	17.5
Sault Sainte Marie	614	11	52	29.52	30.26	+.23	16.8	+4.2	39	8	26	−15	1	8	37	16	13	85	1.81	−.1	13	7.9	se.	27	ne.	27	0	4	18	7.2	18.6	29.4
Chicago	673	7	131	29.44	30.19	+.11	34.6	+8.3	63	13	40	11	1	29	27	32	28	76	2.11	.0	15	12.0	ne.	28	ne.	19	1	4	23	8.9	5.4	.3
Green Bay	617	109	141	29.50	30.21	+.15	25.0	+7.6	41	27	32	−20	1	18	42	23	20	82	3.16	+1.6	14	10.6	n.	31	ne.	19	2	7	19	8.1	9.2	6.0
Milwaukee	681	97	221	29.42	30.18	+.12	31.1	+8.3	57	13	37	3	1	25	27	29	26	82	3.33	+1.5	13	13.7	n.	32	s.	4	3	2	23	8.7	2.9	T
Duluth	1,133	5	47	28.93	30.21	+.13	18.2	+6.8	46	26	26	−19	1	10	30	16	14	87	.63	−.4	12	11.3	ne.	35	nw.	27	8	3	17	6.9	5.6	5.4
North Dakota							7.7	−0.2										88	0.67	+0.2									6.0		
Moorhead, Minn.	940	50	58	29.17	30.25	+.14	9.8	+1.7	41	26	19	−21	18	1	40	10	10	94	.51	−.2	8	8.6	n.	21	nw.	13	5	5	18	7.2	8.5	2.0
Bismarck	1,674	8	57	28.35	30.25	+.13	7.8	−2.5	45	28	17	−25	18	−2	31	8	5	84	.76	+.3	9	7.4	nw.	22	nw.	25	8	10	10	5.7	10.3	.7
Devils Lake	1,478	11	44	28.58	30.27	+.16	5.3	+.2	40	28	14	−22	14	−4	27	5	3	89	.47	.0	5	9.0	nw.	29	ne.	12	7	8	13	6.2	5.0	4.5
Grand Forks	833	12	67																												
Williston	1,878	42	50	28.14	30.24	+.13	7.8	−.3	45	26	17	−27	17	−1	35	7	4	83	.93	+.5	9	6.8	se.	26	se.	10	12	9	7	4.7	11.9	4.0
Upper Mississippi Valley							33.7	+8.8										79	1.81	+0.1									8.0		
Minneapolis-St. Paul, Minn.	919	105	208	29.16	30.19	+.10	21.8	+5.9	44	8	29	−7	1	14	32	21	18	81	.62	−.3	8	10.7	e.	25	w.	13	6	2	20	7.5	7.4	T
La Crosse	714	11	48	29.40	30.20	+.12	27.2	+8.0	47	8	34	−5	1	20	24	25	22	80	1.00	−.1	11	5.9	n.	18	n.	27	2	5	21	8.2	2.7	.0
Madison	974	70	78	29.09	30.19	+.12	28.0	+8.9	47	9	34	0	1	22	23	26	23	82	2.85	+1.4	13	9.1	se.	30	ne.	19	2	4	22	8.7	4.3	T
Charles City	1,015	10	51	29.07	30.20	+.10	26.5	+9.4	48	13	34	2	1	19	32	25	22	84	.58	−.5	8	7.2	se.	18	nw.	13	6	2	20	7.4	2.9	.0
Davenport	606	66	161	29.51	30.19	+.09	34.8	+9.9	66	12	42	10	1	28	35	32	28	79	1.99	+.4	10	11.1	ne.	27	w.	6	2	3	23	8.5	1.7	.0
Des Moines	861	5	99	29.24	30.18	+.07	31.8	+8.1	63	12	40	6	1	24	40	29	26	81	.48	−.7	10	10.3	nw.	25	nw.	6	4	5	19	7.8	2.0	.0
Dubuque	699	60	79	29.41	30.19	+.10	31.6	+9.4	57	13	38	6	1	25	33	29	25	78	1.66	+.3	12	7.0	nw.	19	nw.	13	2	3	23	8.5	1.6	.0
Keokuk	614	64	78	29.50	30.18	+.07	37.1	+8.8	71	12	44	10	1	30	36	33	29	73	1.86	+.3	9	9.1	e.	26	w.	6	3	5	20	8.7	10.7	.0
Cairo	358	87	93	29.80	30.19	+.07	47.8	+9.3	74	12	56	19	1	40	28	43	39	76	2.88	−.2	10	10.9	s.	27	sw.	19	3	7	18	7.7	.1	.0
Peoria	609	11	45	29.51	30.19	+.09	36.2	+10.3	69	12	43	11	1	30	33	34	31	82	2.21	+.2	12	8.6	ne.	21	w.	6	3	7	18	7.9	7.0	T
Springfield, Ill.	636	5	191	29.48	30.18	+.08	39.1	+9.6	73	12	46	13	1	32	34	36	32	78	2.12	−.2	9	12.9	s.	29	nw.	6	1	6	21	8.4	2.4	.0
St. Louis	568	179	303	29.55	30.17	+.06	42.2	+7.4	76	12	49	16	1	35	29	39	35	77	3.51	+1.0	11	14.0	sw.	39	sw.	12	5	5	18	7.1	1.6	.0
Missouri Valley							31.3	+4.9										77	1.35	0.0									6.7		
Columbia, Mo.	784	6	66	29.30	30.16	+.05	40.3	+8.6	73	12	48	15	1	32	32				2.50	+.5	11	9.5	s.	21	sw.	5	5	7	16	7.2	12.9	.0
Kansas City[1]	750	32	45	29.33	30.16	+.05	38.1	+6.9	71	12	47	14	19	29	33	35	31	75	.90	−.8	8	11.4	sw.	34	sw.	12	5	5	18	7.2	4.9	.0
St. Joseph	967	11	49	29.10	30.16		36.2		69	12	46	12	18	27	38	33	29	76	.46	−1.2	7	10.1	nw.	25	nw.	6	7	9	12	6.5	1.1	.0
Springfield, Mo.	1,324	98	104	28.72	30.15	+.04	43.8	+8.6	73	11	52	18	1	36	27	39	35	76	4.53	+2.2	10	11.5	s.	28	w.	6	5	9	14	6.9	6.0	.0
Topeka	987	65	87	29.08	30.16		37.2	+6.2	72	5	47	6	19	27	35	34	29	75	.92	−.6	7	10.7	n.	29	s.	12	4	7	17	7.4	6.6	.0
Lincoln	1,189	11	81	28.86	30.18	+.06	29.8	+3.7	70	12	40	−2	18	20	47	26	22	75	1.21	+.3	3	9.4	n.	27	s.	12	5	8	15	6.5	11.5	.1
Omaha[1]	982	31	44	29.10	30.20	+.09	28.5	+3.0	64	13	38	−6	19	19	46	25	22	81	.91	.0	8	11.0	n.	30	nw.	13	4	8	16	7.4	5.1	.0
Valentine	2,598	47	54	27.37	30.21	+.12	24.4	+3.0	69	11	37	−10	18	12	45	21	16	73	.40	−.2	6	8.2	w.	25	s.	7	9	7	12	5.2	6.0	.0
Sioux City	1,138	64	106	28.93	30.21	+.09	23.5	+2.5	51	7	32	−12	18	15	28	22	18	80	1.02	+.2	4	9.9	nw.	31	nw.	13	4	5	19	7.2	11.0	T
Huron	1,307	59	74	28.76	30.24	+.12	15.9	+1.6	47	26	25	−21	18	7	31	15	11	83	.65	+.1	4	8.4	nw.	25	w.	26	9	8	11	5.8	11.0	T
Northern Slope							23.1	+0.7										71	0.53	−0.1									6.6		
Havre	2,505	11	67	27.45	30.26	+.19	7.6	−6.0	49	26	18	−27	17	−3	38	7	4	83	.62	+.1	10	7.0	e.	25	sw.	6	6	10	12	6.6	8.9	T
Helena	4,124	85	111	25.79	30.16	+.05	19.2	−3.8	47	28	27	−14	16	11	33	17	12	71	.37	−.3	8	5.6	nw.	39	s.	6	5	4	19	7.2	7.8	T
Missoula	3,263	80	91				27.0	+.3	47	6	35	−7	17	19	27				1.35	+.6	9	6.5	se.	53	e.	12	7	4	17	6.7	14.3	T
Kalispell	2,973	48	56	26.92	30.09	+.01	23.4	+.1	40	25	31	−4	16	16	25	22	20	85	1.07	.0	14	5.1	w.	24	n.	12	6	1	21	7.4	17.2	4.9
Miles City	2,371	48	55	27.56	30.19	+.10	13.8	−3.0	53	26	24	−24	17	3	39	12	8	73	.26	−.2	7	5.3	ne.	19	ne.	11	5	13	10	5.9	4.4	T
Rapid City	3,259	50	58	26.65	30.14	+.06	26.5	+3.1	67	26	38	−10	16	15	47	23	18	73	.20	−.3	2	7.2	ne.	26	n.	25	12	10	6	4.6	2.2	.0
Cheyenne[1]	6,144	5	39	23.92	30.10	+.07	30.2	+2.9	60	26	43	−8	16	17	36	25	17	60	.28	−.4	3	11.5	nw.	47	nw.	4	10	6	12	5.6	3.3	.0
Lander	5,352	60	68	24.61	30.06	−.02	28.6	+6.1	60	26	40	−9	16	17	36	23	14	55	.14	−.5	4	6.6	sw.	38	sw.	3	10	12	6	4.5	1.2	.0
Sheridan	3,790	10	47	26.10	30.14		24.0		64	26	38	−12	17	10	44	20	14	66	.31	−.4	7	4.9	nw.	20	sw.	11	8	14	6	4.9	3.5	T
Yellowstone Park	6,241	12	46	23.82	30.15	+.05	24.0	+3.0	51	27	33	−14	16	15	35	20	15	71	.96	+.4	14	8.7	sw.	32	sw.	10	5	8	15	6.9	19.5	6.4
North Platte	2,821	11	51	27.13	30.16	+.09	30.9	+4.3	67	12	44	−5	19	18	44	25	19	70	.25	−.3	3	7.1	w.	28	n.	12	9	10	9	5.7	3.6	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, February 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles							0–10	In.	In.
Middle Slope							38.6	+4.8										62	1.64	+0.8									6.0		
Denver	5,292	106	113	24.72	30.08	+0.07	37.2	+4.5	66	11	49	2	16	26	39	28	16	46	0.43	−.1	4	7.7	s.	25	sw.	12	11	6	11	5.1	6.7	0.0
Pueblo	4,685	80	86	25.30	30.06	+.06	38.4	+5.5	71	8	51	13	16	26	45	30	19	50	.70	+.2	6	7.3	nw.	34	nw.	4	11	9	8	5.2	9.1	.0
Concordia	1,392	50	58	28.65	30.17	+.08	33.4	+3.6	73	8	44	0	19	23	38	29	24	73	1.48	+.6	3	8.7	n.	24	sw.	8	5	15	8	5.6	1.6	T
Dodge City	2,509	10	86	27.46	30.13	+.07	37.8	+4.6	78	11	49	6	19	26	47	31	22	61	1.08	+.3	6	11.6	n.	35	s.	1	4	12	12	6.6	4.1	T
Wichita	1,358	85	93	28.68	30.15	+.07	38.9	+4.5	74	11	48	4	20	29	32	34	28	70	2.48	+1.2	7	11.3	nw.	35	sw.	8	8	7	13	6.0	9.3	T
Oklahoma City	1,214	10	47	28.83	30.14	+.07	45.6	+6.0	75	11	55	14	19	36	32	41	36	75	3.66	+2.6	6	11.5	s.	28	s.	1	3	11	14	7.3	2.2	.0
Southern Slope							50.8	+4.9										65	1.33	+0.6									6.9		
Abilene	1,738	10	52	28.30	30.13	+.08	52.4	+5.2	80	13	63	26	22	42	34	46	40	69	1.23	+.2	6	10.2	s.	29	nw.	18	3	7	18	7.6	3.5	.0
Amarillo	3,676	10	49	26.32	30.12	+.10	42.9	+4.8	77	12	54	17	18	32	37	35	26	62	2.87	+2.2	9	9.2	w.	34	w.	2	2	12	14	7.1	15.7	.0
Del Rio	960	63	71	29.08	30.08	+.08	60.3	+4.3	81	27	68	32	1	53	29	54	49	70	.30	−.2	7	9.2	se.	32	nw.	18	4	6	18	7.2	.0	.0
Roswell	3,566	75	85	26.42	30.07	+.09	47.7	+5.2	75	8	61	18	18	34	44	40	31	60	.93	+.4	4	7.7	s.	28	s.	17	5	17	6	5.8	.6	.0
Southern Plateau							45.8	+1.3										54	1.09	+0.3									5.8		
El Paso	3,778	82	101	26.23	30.03	+.08	53.8	+4.8	78	10	67	28	18	41	37	42	29	43	.17	−.2	4	6.9	e.	23	nw.	17	14	7	7	4.6	.0	.0
Albuquerque [1]	4,972	5	39	25.08	30.05	.....	40.4	−.1	67	9	54	14	18	27	37	33	24	54	.49	+.2	5	7.5	n.	31	w.	5	4	9	15	7.0	2.5	.0
Santa Fe	7,013	38	53	23.24	30.08	+.10	35.6	+2.5	59	9	45	11	18	26	29	29	21	57	1.02	+.3	10	5.4	e.	22	sw.	12	4	8	16	7.1	7.3	.0
Flagstaff	6,907	10	59	23.31	30.00	.00	30.4	−.4	50	26	41	−6	17	20	41	28	.....	75	3.72	+1.4	11	8.1	sw.	28	sw.	11	2	15	11	.....	21.5	T
Phoenix	1,107	39	51	28.87	30.03	+.04	56.4	+1.3	77	7	68	34	18	45	34	47	36	52	.55	−.2	6	5.2	e.	15	w.	12	9	8	11	5.8	.0	.0
Yuma	141	9	54	29.91	30.06	+.06	58.2	−.4	78	10	70	35	18	46	34	48	34	45	.58	+.2	4	5.8	n.	23	n.	20	14	6	8	4.3	.0	.0
Independence	3,957	5	26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Middle Plateau							34.8	+1.4										66	1.62	+0.7									8.1		
Reno	4,527	61	76	25.40	30.00	−.08	33.2	−3.1	52	27	42	8	17	24	30	30	25	72	3.87	+2.7	12	6.5	s.	28	se.	2	4	16	8	5.9	32.4	T
Tonopah	6,090	12	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.56	30.01	−.08	34.8	+1.3	54	27	44	3	17	26	32	31	26	70	1.16	+.2	10	9.6	sw.	35	sw.	9	5	4	19	7.9	10.4	.0
Modena	5,473	10	43	24.60	30.02	−.02	32.9	+1.9	52	11	42	9	18	24	32	29	23	68	1.16	+.2	11	9.4	sw.	36	s.	11	10	4	14	6.2	6.8	.0
Salt Lake City [1]	4,527	32	46	25.73	30.05	−.03	36.9	.....	58	11	45	10	18	29	28	33	27	67	.89	.....	9	10.5	se.	35	w.	12	4	9	15	7.3	12.5	.0
Grand Junction	4,602	60	68	25.40	30.03	−.01	38.2	+5.3	60	11	48	15	18	28	29	32	23	55	.31	−.3	5	7.1	se.	25	s.	12	6	10	12	6.1	.1	.0
Northern Plateau							35.9	+3.3										73	1.58	+0.2									7.9		
Baker	3,471	36	54	26.38	30.02	−.10	33.8	+4.8	54	27	42	4	17	26	29	31	27	75	1.51	+.3	12	7.4	se.	25	s.	9	3	7	18	7.5	17.3	.0
Boise	2,739	79	87	27.15	30.04	−.08	40.6	+5.8	59	27	48	21	17	34	27	35	28	61	.82	−.6	9	8.1	se.	25	se.	9	5	3	20	7.6	4.8	.0
Pocatello	4,477	60	68	25.45	30.05	−.05	34.4	+5.5	55	27	41	27	6	28	27	30	24	66	1.32	.0	12	10.0	s.	37	s.	9	4	6	18	7.5	9.6	.0
Spokane	1,929	101	110	27.92	30.02	−.07	33.6	+2.3	51	28	40	19	13	27	25	31	28	79	1.90	+.1	14	6.2	s.	27	se.	6	4	5	19	7.8	21.1	.6
Walla Walla	991	57	65	28.91	30.00	−.11	38.2	+1.1	53	5	44	20	1	33	21	35	31	78	2.18	+.4	13	5.4	s.	30	se.	13	1	3	24	8.6	8.5	.0
Yakima	1,076	58	67	28.82	29.99	.....	35.0	+.5	48	12	41	17	5	29	24	33	30	80	1.77	+.8	14	4.2	nw.	16	sw.	5	1	5	22	8.6	9.7	.0
North Pacific Coast Region							44.0	+1.9										77	6.13	+0.6									7.6		
North Head	211	11	56	29.63	29.86	−.20	44.8	+1.8	67	26	50	34	4	40	19	42	39	81	6.09	−1.4	21	15.7	e.	66	s.	5	7	3	18	7.0	T	.0
Seattle	125	90	321	29.75	29.88	−.18	44.4	+3.3	70	28	51	32	17	38	33	41	36	72	2.82	−1.1	17	8.5	se.	37	s.	3	5	5	18	7.4	T	.0
Tatoosh Island	86	10	54	29.73	29.83	−.17	43.0	+2.0	56	24	46	34	4	40	11	41	38	81	6.37	−3.1	18	17.9	e.	44	sw.	6	6	2	20	7.5	.2	.0
Medford [1]	1,329	29	58	28.51	29.94	.....	41.5	.....	69	26	50	24	16	33	37	38	34	78	4.65	+2.3	16	.....	n.	.....	.....	.....	3	3	22	7.9	8.2	.0
Portland, Oreg	153	68	106	29.75	29.91	−.17	43.4	+1.3	57	25	48	31	1	39	16	40	36	75	7.83	+2.5	18	6.8	e.	23	se.	3	5	4	19	7.6	1.4	.0
Roseburg	510	45	76	29.36	29.91	−.19	44.6	+1.2	74	24	53	28	17	36	39	42	37	77	9.04	+4.6	20	4.2	s.	18	s.	13	3	3	22	8.0	1.0	.0
Middle Pacific Coast Region							49.8	0.0										74	10.24	+5.2									7.4		
Eureka	62	73	89	29.88	29.96	−.15	48.5	+1.3	72	28	54	35	15	43	23	45	41	77	13.94	+7.5	20	7.9	se.	35	sw.	28	4	3	21	7.7	.0	.0
Redding [1]	722	20	34	.....	.....	.....	47.4	−2.3	71	23	54	33	4	41	26	42	36	69	10.28	+3.7	17	11.2	nw.	41	se.	9	4	3	21	7.9	2.6	.0
Sacramento	66	92	115	29.95	30.02	−.07	50.3	+.2	70	24	57	35	19	43	25	47	43	76	8.24	+5.2	16	9.2	se.	46	s.	9	5	8	15	6.7	.0	.0
San Francisco	155	112	132	29.83	30.00	−.10	53.0	+.8	71	23	59	42	16	47	24	49	44	74	8.49	+4.6	16	8.2	e.	38	sw.	9	4	8	16	7.1	.0	.0
South Pacific Coast Region							55.5	+1.6										69	5.68	+3.5									5.7		
Fresno	327	97	105	29.71	30.07	−.01	52.4	+1.3	74	26	60	36	17	44	27	48	42	70	3.98	+2.6	10	7.1	se.	35	se.	9	7	10	11	6.3	.0	.0
Los Angeles	338	159	191	29.70	30.07	+.01	56.8	+1.3	76	23	64	42	13	49	24	50	43	64	9.81	+6.7	14	7.5	ne.	26	e.	9	14	3	11	4.8	.0	.0
San Diego	87	62	70	29.97	30.07	+.01	57.2	+2.1	79	25	64	43	14	50	27	51	46	72	3.26	+1.2	13	6.8	e.	34	s.	27	10	4	14	6.0	.0	.0
West Indies																															
San Juan, P. R.	82	9	54	29.97	30.06	.....	73.6	−1.3	86	25	78	65	20	69	17	.....	.....	.....	2.26	−.5	16	15.8	e.	37	e.	6	11	16	1	4.1	.0	.0
Panama Canal																															
Balboa Heights	118	6	92	.....	[3] 29.88	+.02	80.0	−.3	90	20	88	70	28	72	20	.....	.....	[3] 72	.01	−.6	1	10.0	nw.	27	n.	22	16	12	0	3.8	.0	.0
Cristobal	36	6	97	.....	[3] 29.91	+.02	80.8	.0	85	9	84	75	1	77	10	73	71	[3] 78	1.11	−.4	12	16.5	n.	30	n.	1	7	18	3	4.9	.0	.0
Alaska																															
Fairbanks	454	11	87	[3] 29.64	[3] 30.23	.....	−11.4	−10.6	45	28	0	−50	6	−23	38	−10	−15	75	.40	−.1	6	4.2	n.	24	sw.	22	13	6	9	4.3	13.3	24.5
Juneau	80	96	116	[3] 29.82	[3] 29.91	.....	24.2	−6.0	57	27	28	3	7	20	19	22	12	59	6.10	+.7	11	12.6	ne.	38	ne.	8	7	6	15	6.5	19.3	.0
Nome	22	5	32	[1] 30.15	[3] 30.16	.....	6.0	−.8	32	14	14	−34	26	−2	35	6	1	65	.81	.0	9	10.0	ne.	42	ne.	27	12	6	10	4.8	6.4	7.0
Hawaiian Islands																															
Honolulu	38	86	100	29.89	29.93	.....	73.4	+2.6	81	1	78	65	5	69	14	69	67	81	5.05	+1.3	14	7.8	e.	30	w.	27	7	13	8	5.9	.0	.0

[1] Observations taken at airport.
[3] Observations taken bihourly.
[3] Pressure not reduced to a mean of 24 hours.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, February 1938*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min÷2.	Departure from normal	Mean maximum.	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F*	*°F*	*°F.*	*°F*	*°F*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	29.99	30.05	+0.14	17.2	−2.6	25.0	9.4	40	−5	2.98	−1.43	12.7
Halifax, Nova Scotia	88	29.84	30.11	+.16	21.0	−2.0	27.6	14.5	44	2	2.40	−2.01	7.6
Yarmouth, Nova Scotia	65	30.01	30.13	+.17	25.0	−.4	31.4	18.5	45	9	3.42	−.88	19.4
Charlottetown, Prince Edward Island	38	30.05	30.14	+.22	14.3	−2.3	22.5	6.0	40	−10	3.81	+.54	28.7
Chatham, New Brunswick	28	30.01	30.13	+.18	12.4	−1.2	23.0	1.9	37	−22	1.79	−.93	17.9
Father Point, Quebec	20												
Quebec, Quebec	296	29.85	30.21	+.20	13.8	+2.3	21.1	6.5	34	−13	2.34	−.79	23.3
Doucet, Quebec	1,236	28.82	30.26	+.24	−.8	−.6	15.8	−17.4	32	−53	3.12	+1.54	31.2
Montreal, Quebec	187												
Ottawa, Ontario	236	29.94	30.22	+.18	14.4	+2.2	23.1	5.8	38	−13	2.20	−.29	10.3
Kingston, Ontario	285	29.88	30.20	+.14	23.8	+7.0	30.3	17.3	43	−8	3.75	+1.56	4.4
Toronto, Ontario	379	29.78	30.22	+.15	27.2	+6.7	33.9	20.5	51	−4	3.62	+1.14	3.6
Cochrane, Ontario	930	29.17	30.25	+.16	3.1	−.5	14.9	−8.6	32	−34	2.02	+1.11	20.1
White River, Ontario	1,244	28.84	30.28	+.22	4.6	+7.4	19.5	−10.2	37	−50	2.19	+.94	21.9
London, Ontario	808	29.28	30.19	+.09	27.8	+8.0	34.7	20.9	55	0	6.02	+2.58	5.6
Southampton, Ontario	656	29.46	30.20	+.17	23.4	+3.8	30.4	16.4	49	−2	4.53	+1.69	9.9
Parry Sound, Ontario	688	29.50	30.24	+.17	18.8	+5.7	27.5	10.2	40	−11	4.42	+1.54	11.2
Port Arthur, Ontario	644	29.52	30.27	+.19	11.7	+2.7	22.3	1.0	46	−30	3.06	+2.37	30.8
Winnipeg, Manitoba	760	29.38	30.28	+.10	4.6	+3.0	14.3	−5.1	47	−33	1.72	+.88	17.2
Minnedosa, Manitoba	1,690	28.36	30.30	+.16	3.4	+3.2	12.8	−6.1	44	−34	3.66	+3.09	36.6
Le Pas, Manitoba	860	29.27	30.32	+.15	−1.3	+2.2	9.1	−11.6	50	−34	1.02	+.49	10.2
Qu'Appelle, Saskatchewan	2,115	27.82	30.24	+.08	2.8	−1.6	12.4	−6.9	51	−36	2.06	+1.33	20.8
Moose Jaw, Saskatchewan	1,759	28.14	30.26	+.09	5.2	−1.9	15.0	−4.7	51	−31	1.92	+1.44	19.2
Swift Current, Saskatchewan	2,392	27.52	30.26	+.11	5.8	−2.9	13.2	−1.7	46	25	1.79	+1.20	17.9
Medicine Hat, Alberta	2,365	27.61	30.25	+.12	6.1	−9.4	15.7	−3.6	47	−32	1.26	+.68	12.6
Calgary, Alberta	3,540	26.34	30.26	+.15	5.9	−8.6	15.4	−3.6	61	−30	.69	+.11	6.9
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.66	30.34	+.19	.3	−1.1	10.7	−10.0	51	−42	.66	+.07	6.6
Battleford, Saskatchewan	1,592	28.44	30.30	+.15	−3.3	−2.6	8.4	−15.0	49	−46	.88	+.51	8.8
Edmonton, Alberta	2,150	27.82	30.27	+.20	2.8	−8.8	12.0	−6.4	58	−32	.99	+.33	9.9
Kamloops, British Columbia	1,262	28.69	30.09	+.01	26.6	−.2	33.7	19.5	46	−3	1.39	+.69	13.9
Victoria, British Columbia	230	29.62	29.87	−.16	41.7	+1.3	46.6	36.8	57	31	1.81	−1.36	T
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	29.78	29.80	−.18	41.0	.0	46.8	35.3	58	29	11.72	+.49	T
Prince Rupert, British Columbia	170	29.60	29.78	−.13	36.8	+.2	42.2	31.4	66	20	1.83	−6.49	.3
St. George's, Bermuda	151		30.17	+.06	61.9	+.1	67.0	56.7	74	51	1.94	−2.76	.0
LATE REPORTS FOR JANUARY 1938													
Cape Race, Newfoundland	99				23.6	−1.4	30.7	16.4	43	−5	6.01	+1.37	10.9
Kamloops, British Columbia	1,262	28.83	30.24	+0.11	28.0	+6.2	32.3	23.8	48	4	.48	−.52	4.8
Victoria, British Columbia	230												
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	30.00	30.04	+.05	43.8	+3.6	48.4	39.3	58	32	10.16	−2.26	.0
Prince Rupert, British Columbia	170	29.68	29.86	−.01	39.2	+4.0	43.4	35.0	51	19	8.61	−1.11	7.7

TABLE 4.—*Severe local storms, February 1938*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Osage, Iowa	5	5 p. m.				Electrical and hail	2 inches of hail fell in 30 minutes; trees damaged.
Detroit, Mich., vicinity of	5–6					Heavy rain	Streams and rivers overflowed their banks causing much damage.
Amsterdam, N. Y., and vicinity	8				$100,000	Rain and flood	Rain and warm weather caused the ice-jammed Mohawk River to overflow, flooding cities and farmlands for miles along the river. Greatest damage in Amsterdam estimated to be $100,000.
California, central and northern portions	9			6	1,000,000	Straight-line wind	Severe storm entered State from the Pacific Ocean. Many shade and orchard trees blown down; severe damage to communication and power lines; many garage and farm buildings unroofed. Damage most severe in San Francisco Bay region, northern San Joaquin and Sacramento Valleys.
Madera, Calif., vicinity of	11					Heavy rain	Small streams draining lower foothills basins overflowed. Highways flooded and railroad tracks washed out.
Harrisburg, Pa	11	p. m.				Snow and mist	Highways dangerous because of light snow and freezing mist. Number of traffic accidents reported.
Baltimore, Md	11–12					Glaze	Ice on all exposed objects.
Walnut, Ill., 3 miles southeast	12					Electrical	Considerable damage to a farm residence.
Missoula, Mont., and vicinity	12	4 a. m.			500	Wind and snow	Much drifting; wind of 53 miles an hour recorded.
Grand Rapids, Mich	12–13	12:30 p. m.			30,000	Thunderstorms and heavy rain.	Streets and sewers flooded. Small damage to power lines by lightning. Portion of the southern section of the city under water from the overflow of Plaster Creek. $30,000 damage to large industrial plant.
South Dakota, Walworth to Potter Counties, eastward to the State line.	12–13					Sleet	Wires ice-coated; poles and wires blown down.
Duluth, Minn., and vicinity	13	a. m.			5,000	Glaze, sleet, and snow.	Number of poles and wires down; traffic delayed.
Marquette, Mich	13–14					Rain, sleet, and dust.	Dust from 11:50 a. m., to about 12:35 p. m. Rain and sleet alternated at frequent intervals all day. Artificial light necessary in homes and motorists used headlights. By a. m. of the 14th a brown layer nearly one-half inch thick could be seen by brushing off the fresh snow that had fallen during the night.
Dodge City, Kans	14–17					Sleet and glaze	Some damage to wires and trees. Numerous minor accidents, because of icy pavements.
Oklahoma, eastern portion of State.	14–21				750,000	Flood	Heavy rain and melted snow resulted in the overflow of many minor streams Buildings, fences, highways and bridges damaged. Hundreds of livestock drowned in swollen streams. Many farmhouses washed away and land erosion severe in some parts of the flooded area.
Concordia, Kans	15–17					Rain, sleet, and snow.	Extensive damage to the power and communication lines.
Iowa, entire State [1] except the eastern portion.	16			2		Snow and glaze	All roads except those in the eastern part of the State ice-coated and slippery. Driving hazardous.
Rodessa, La	17	9:45 p. m.	150	21	250,000	Tornado	Wreckage of oil derricks, machinery, and buildings strewn along a path 1½ miles long. 40 persons injured.
Detroit, Mich	17	6–10 a. m.				Glaze	Light rain and low temperature caused all surfaces to be ice-coated.
Grand Rapids, Mich	17					do	Streets and walks covered with glaze. Several persons injured.
Mertzon and Sherwood, Tex	17	3:20 a. m.	400	0	50,000	Tornado	Main damage at Mertzon. Approximately 24 persons injured, 2 critically. Buildings demolished in the business section.
Wichita, Kans	17–19			1		Snow	This storm severe for February at this station. One person died of exposure.
Petrey, Ala	18			1	1,000	Wind	Property damaged.
Columbia, Mo	19	12:35 a. m.				Snow	Rain before midnight formed a thin coating of ice on streets and highways, after which 11.8 inches of snow fell.
Dayton, Ohio, and vicinity	19	5:16 p. m.				do	3 inches of slush on roads. Most extensive trouble from the heavy wet snow to communication lines.
Chicago, Ill. [1]	19					do	Transportation delayed because of blinding snow, 3 inches falling. Most highways in northern and west-central Illinois covered with ice or snow.
Providence, R. I	25–26			2		Snow and ice	Snow that fell on the 25th caused icy streets and highways on the 26th.
Tucker County, W. Va., and vicinity.	27					Glaze	Ice on highways in mountainous districts caused travel to be extremely hazardous. Much damage to telephones, wires, and poles.
New England [1]	28			1		Snow and wind	
Pennsylvania, western portion	28					Snow	8 inches of snow fell in the mountainous sections of Somerset County on the southwest and 5 inches in the Bradford area on the north.

[1] From press reports.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, February 1938

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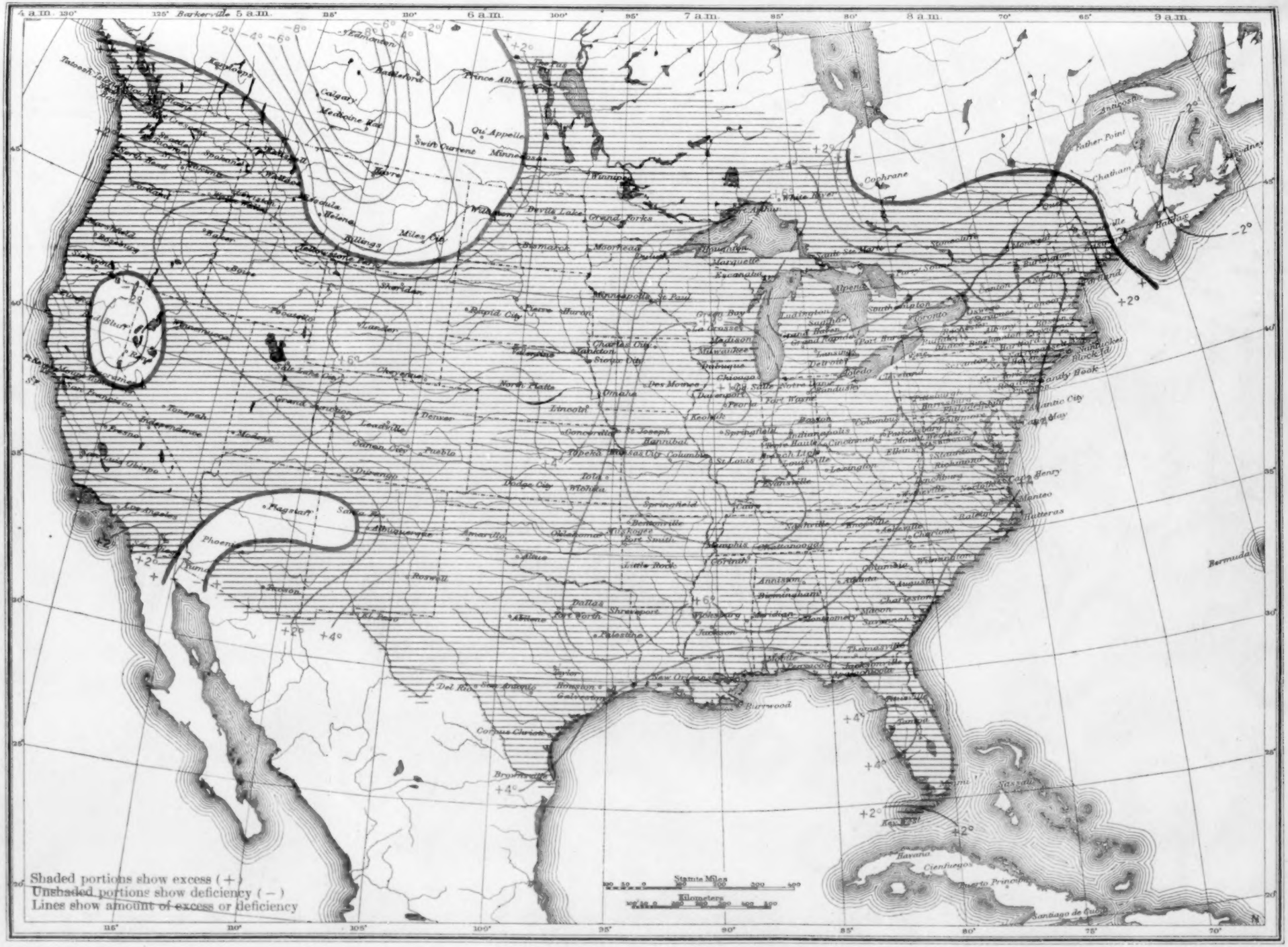
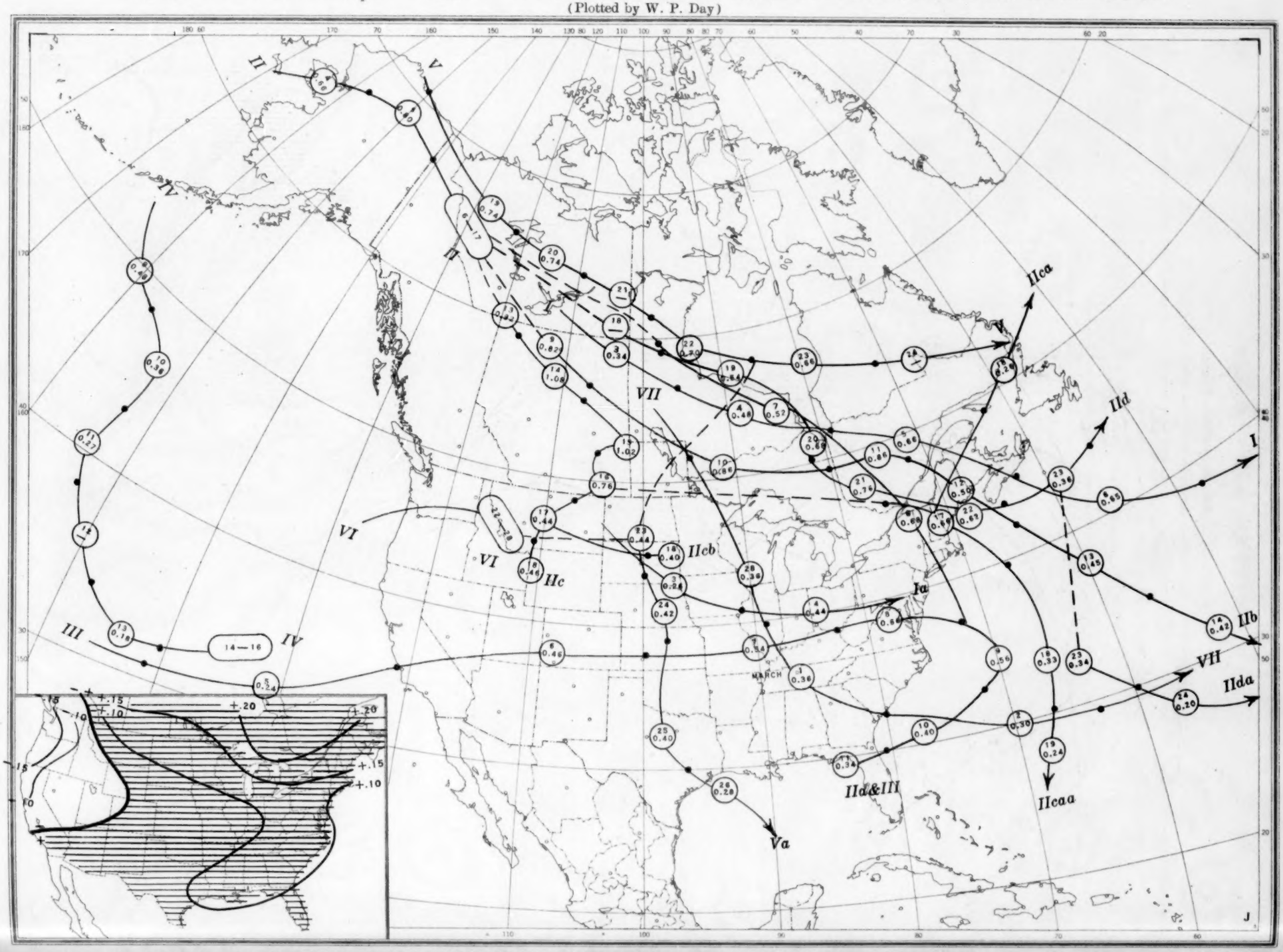

Shaded portions show excess (+)
Unshaded portions show deficiency (−)
Lines show amount of excess or deficiency
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, February 1938. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

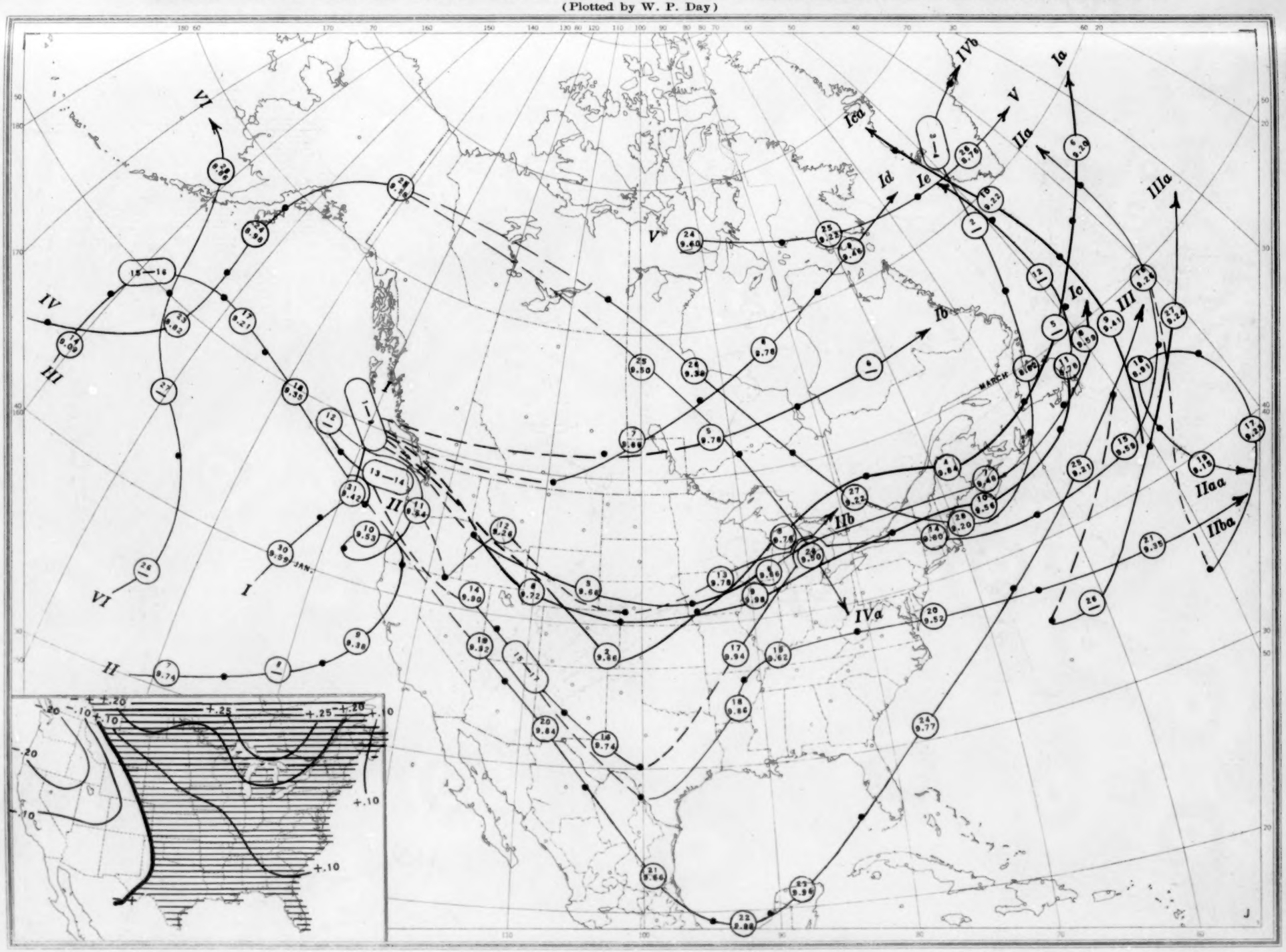
Chart III. Tracks of Centers of Cyclones, February 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, February 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, February 1938

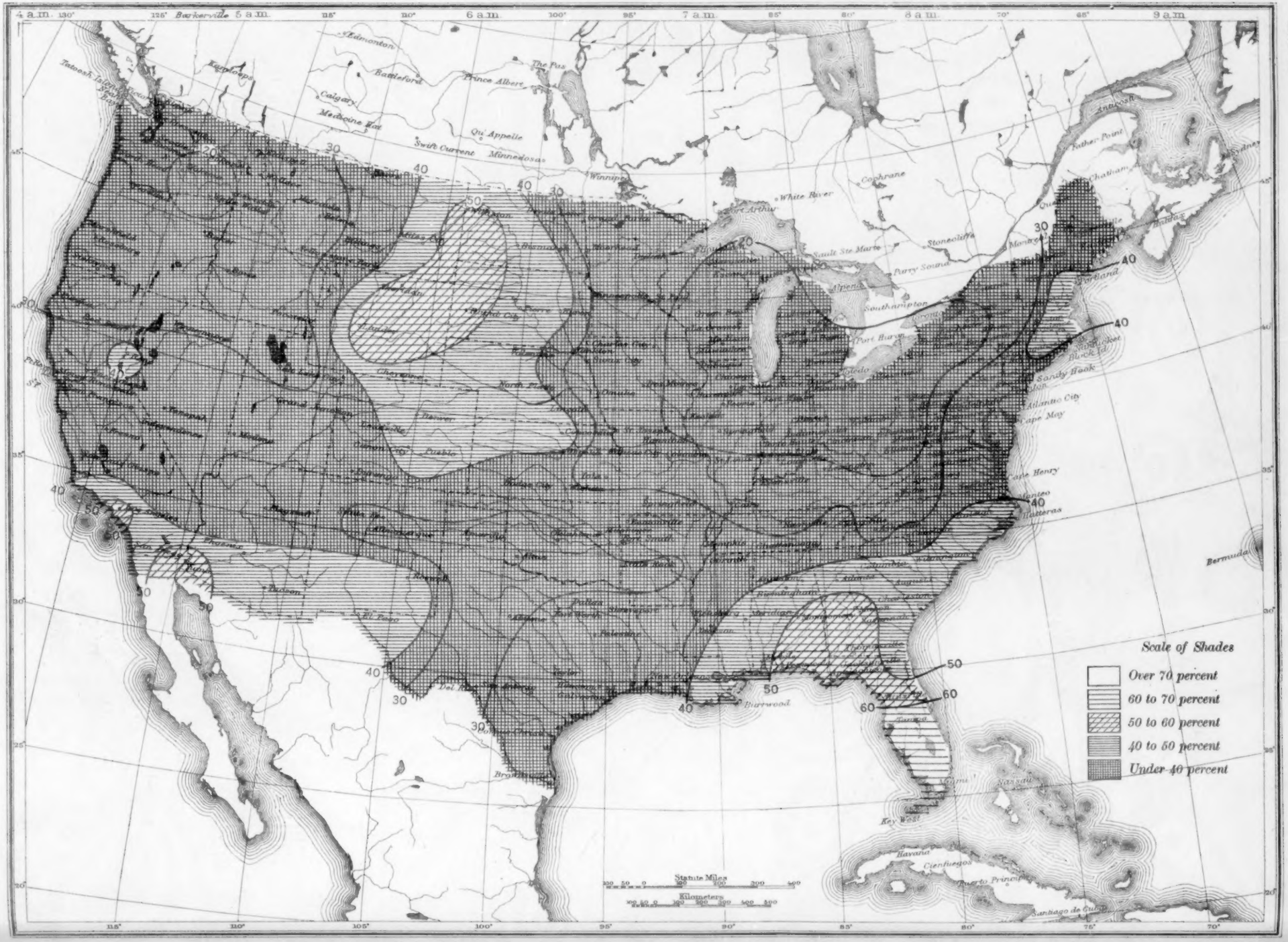


Chart V. Total Precipitation, Inches, February 1938. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, February 1938. (Inset) Departure of Precipitation from Normal

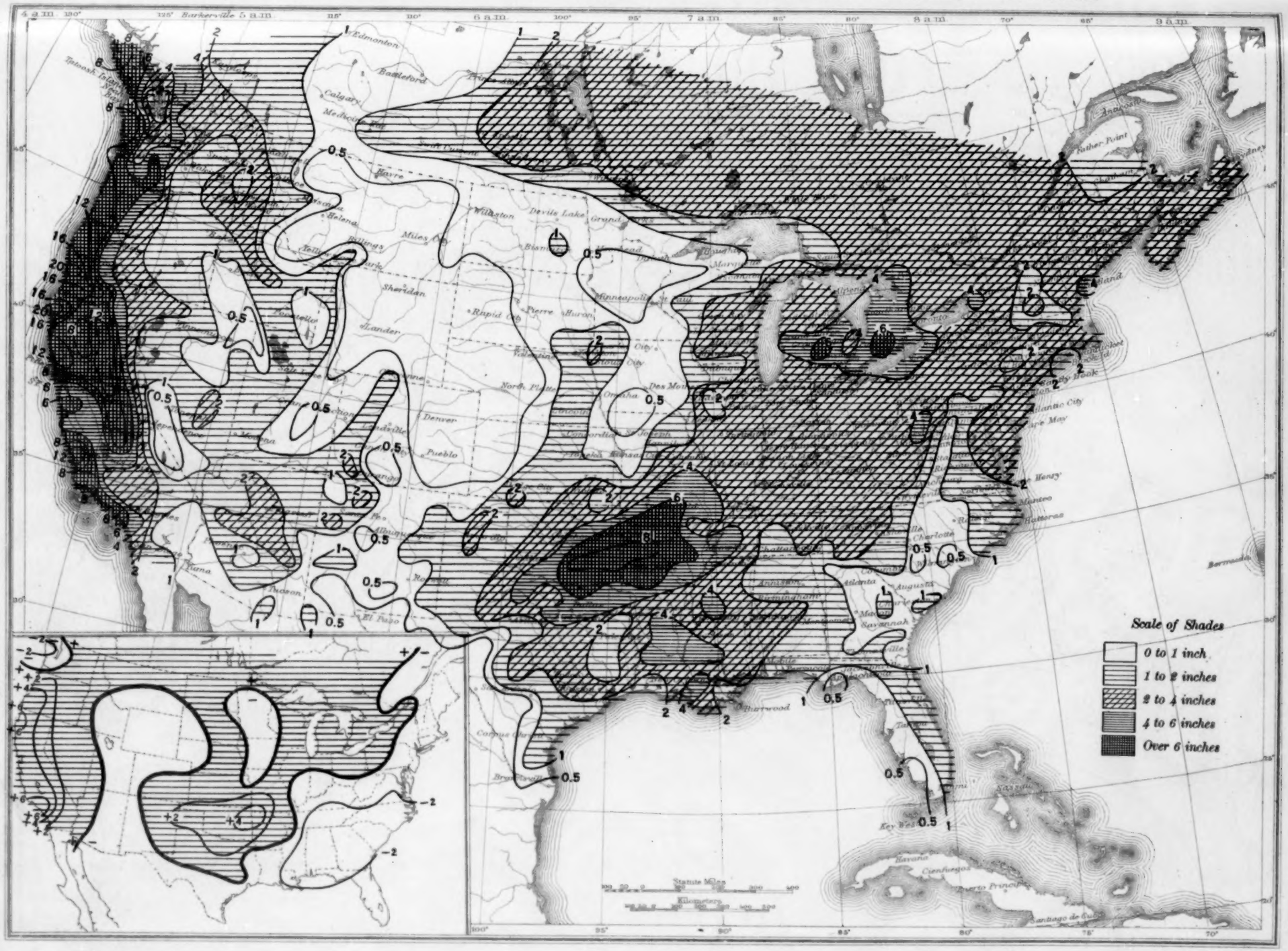


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, February 1938

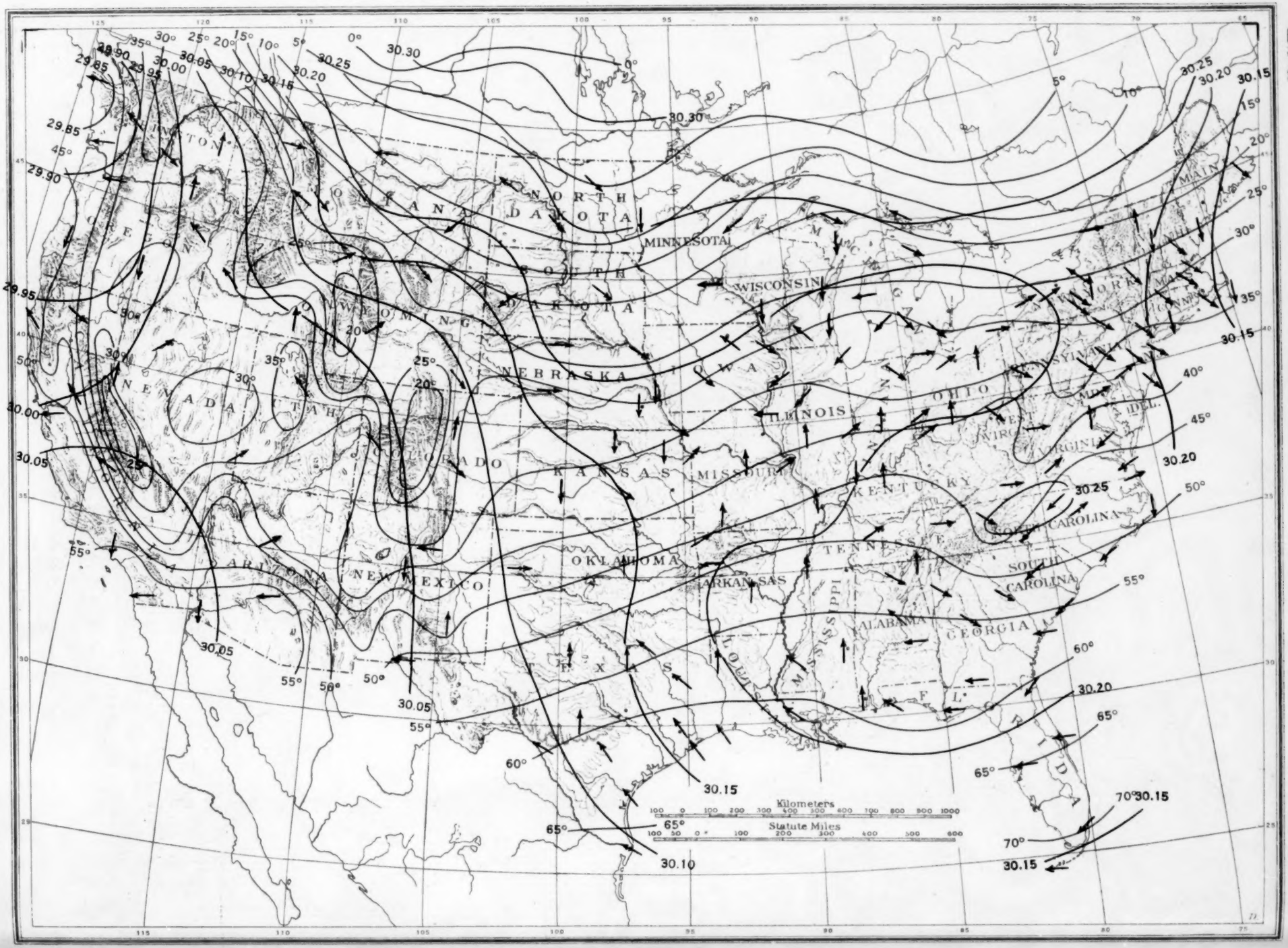


Chart VII. Wind Roses for Selected Stations, February 1938

(Plotted by W. W. Reed)

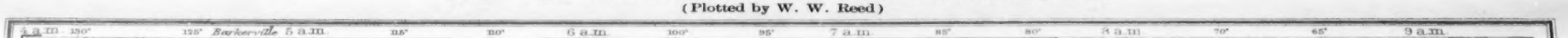
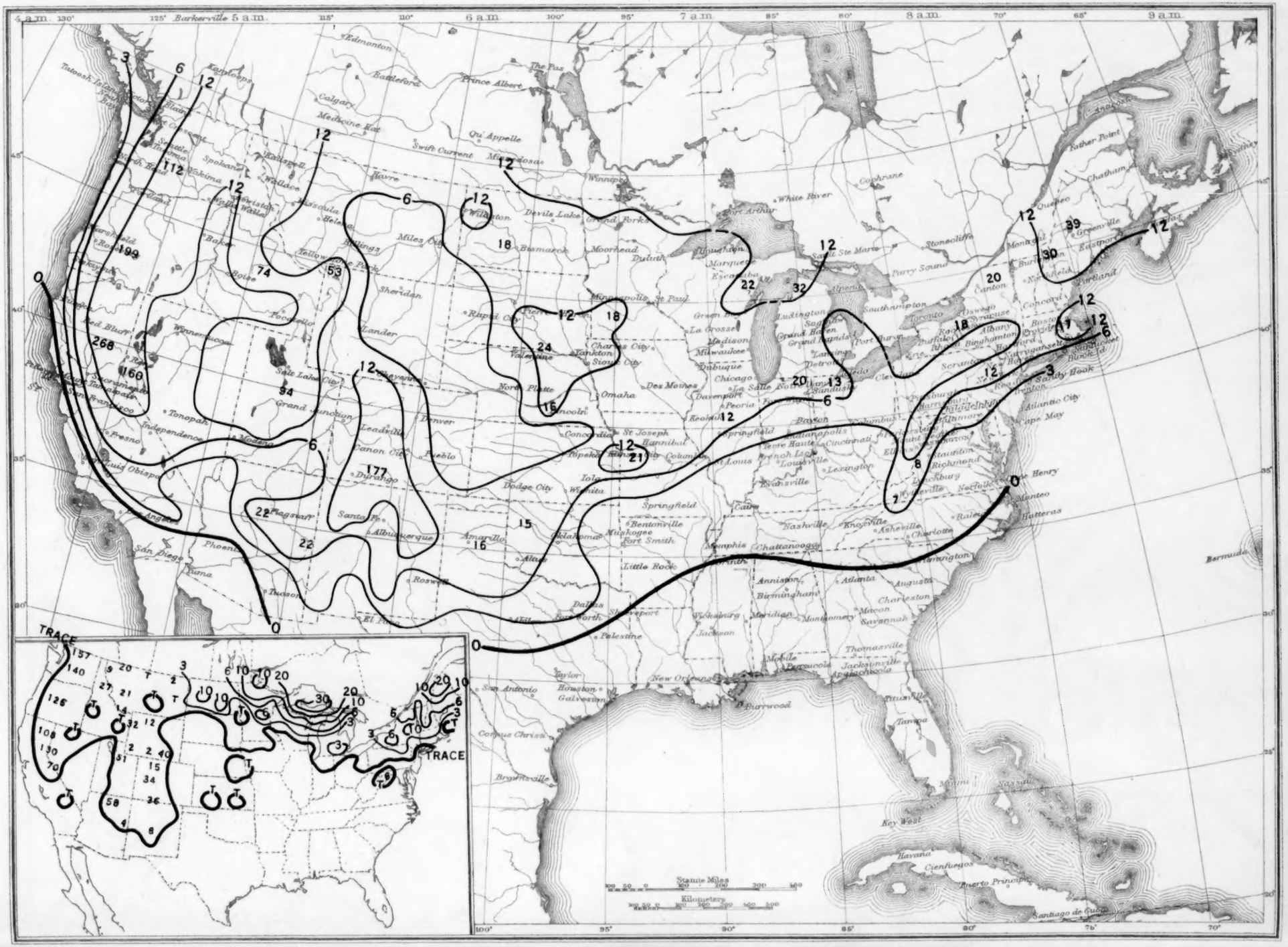


Chart VII. Wind Roses for Selected Stations, February 1938

(Plotted by W. W. Reed)

Chart VIII. Total Snowfall, Inches, Jan. 1938. (Inset) Depth of Snow on Ground at 7:30 p.m., Monday, February 28 1938



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February 1938. M. W. R.

Chart IX. Weather Map of North Atlantic Ocean, February 8, 1938
(Plotted from the Weather Bureau Northern Hemisphere Chart)

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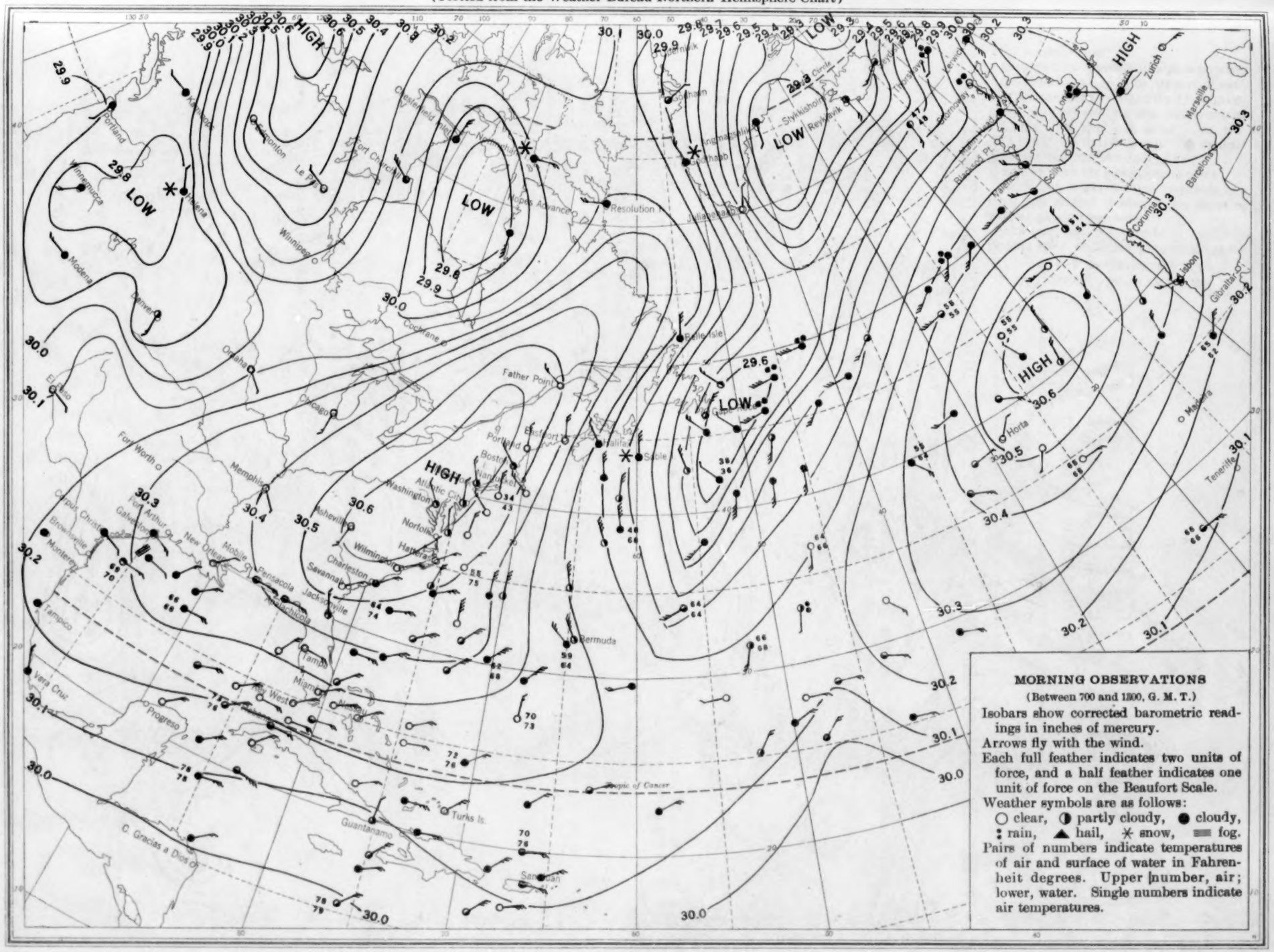
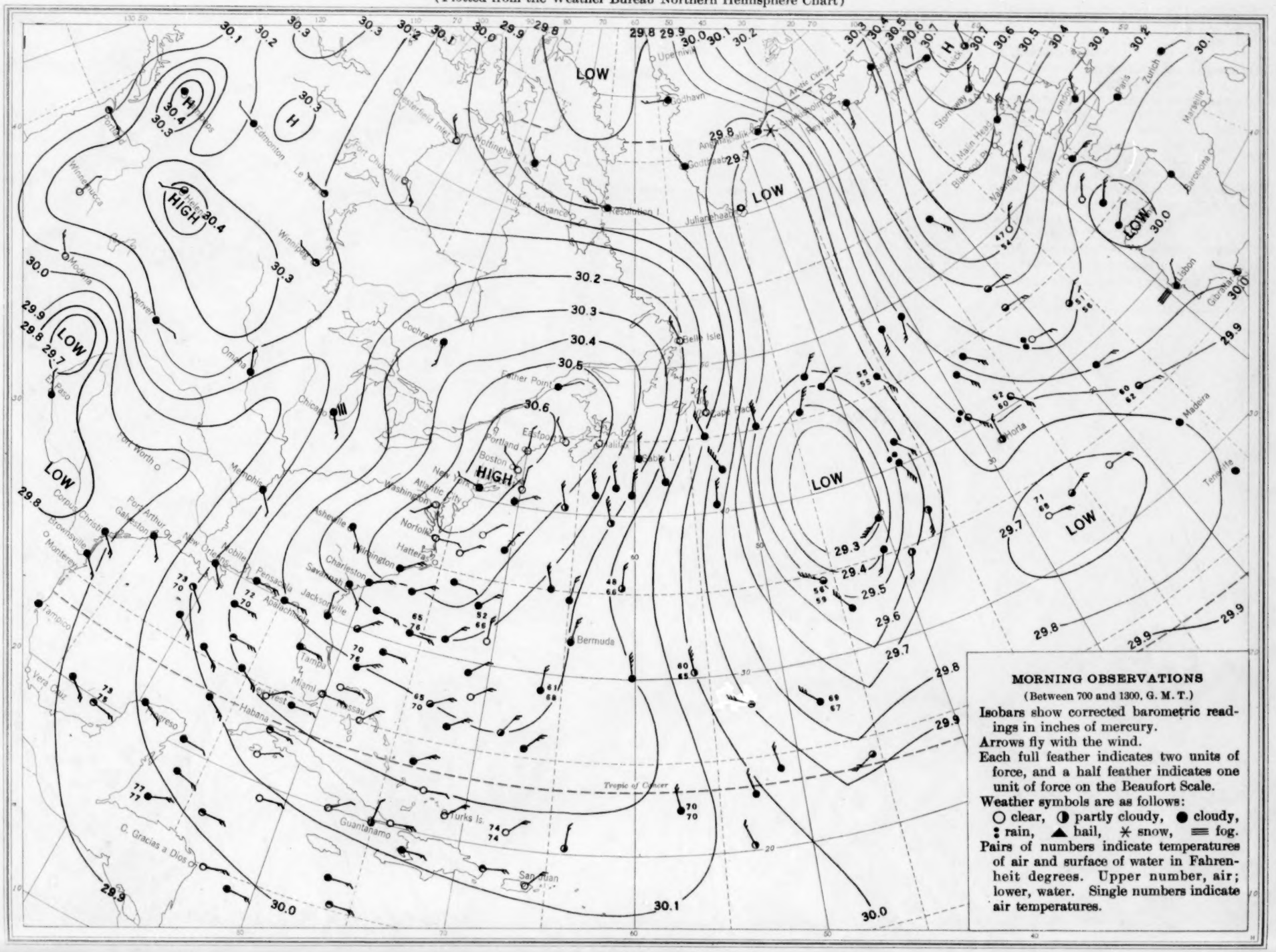


Chart X. Weather Map of North Atlantic Ocean, February 17, 1938

(Plotted from the Weather Bureau Northern Hemisphere Chart)